THE AEROPLANE and ASTRONAUTICS

JANUARY 27, 1961

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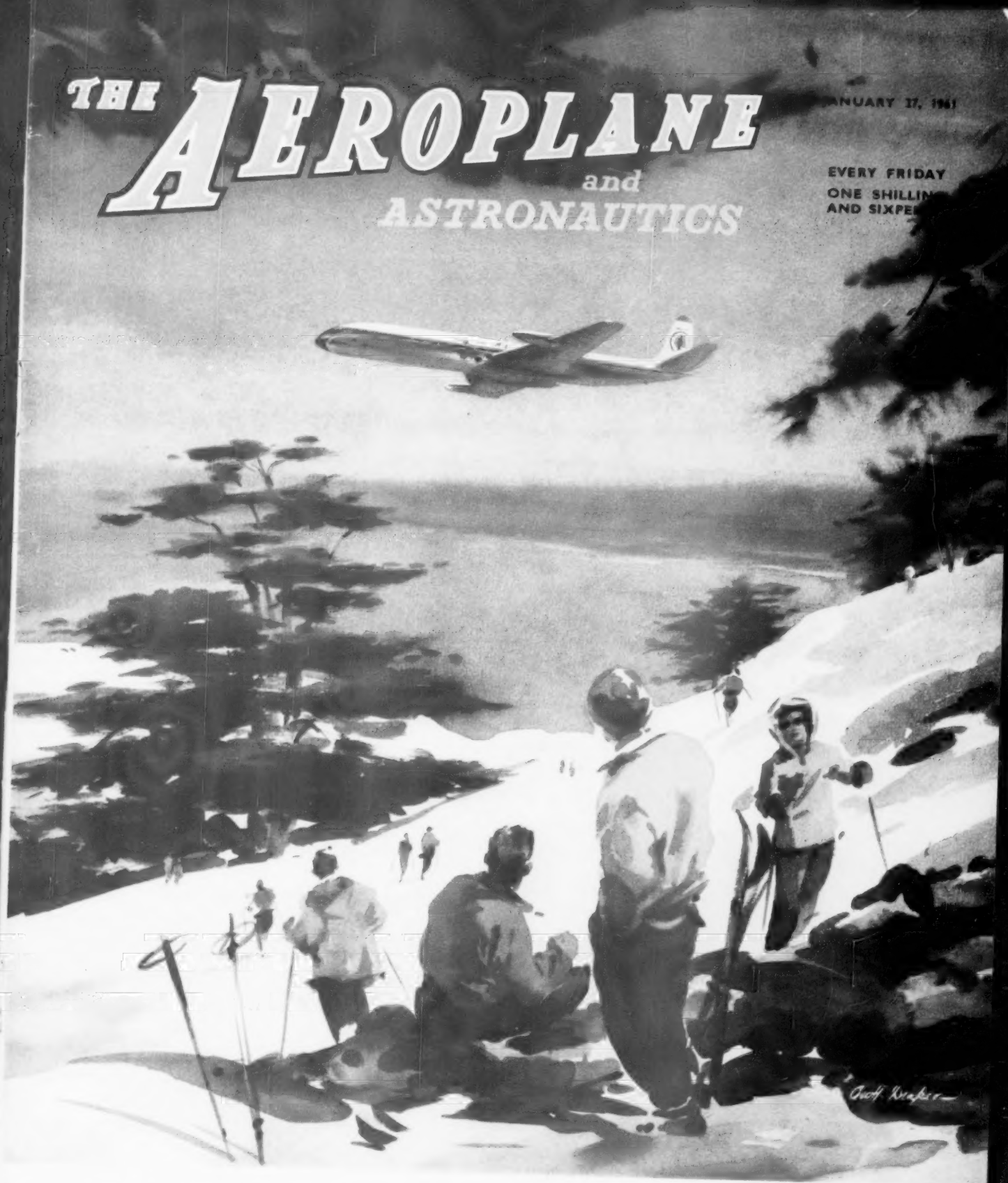
AND SIXPE



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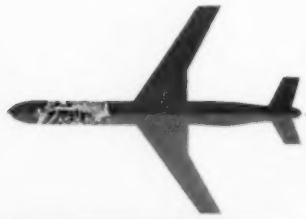

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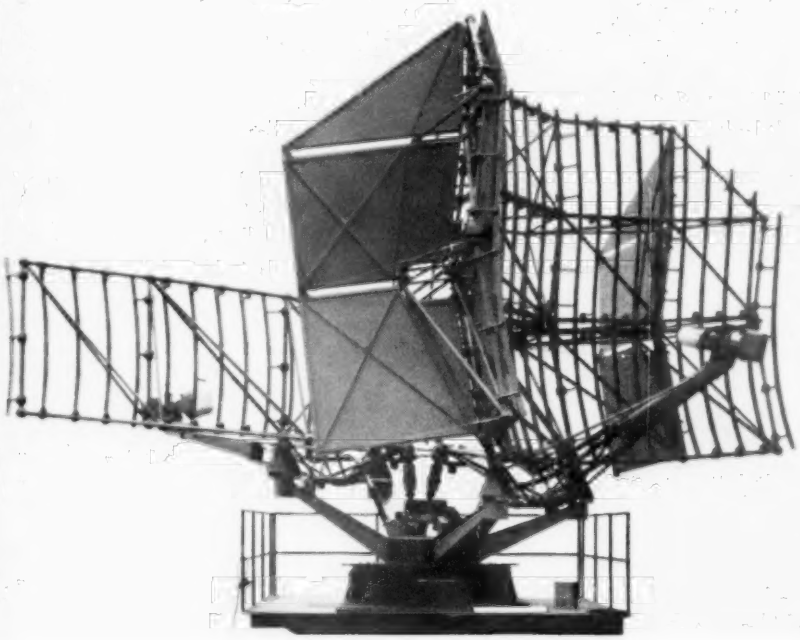

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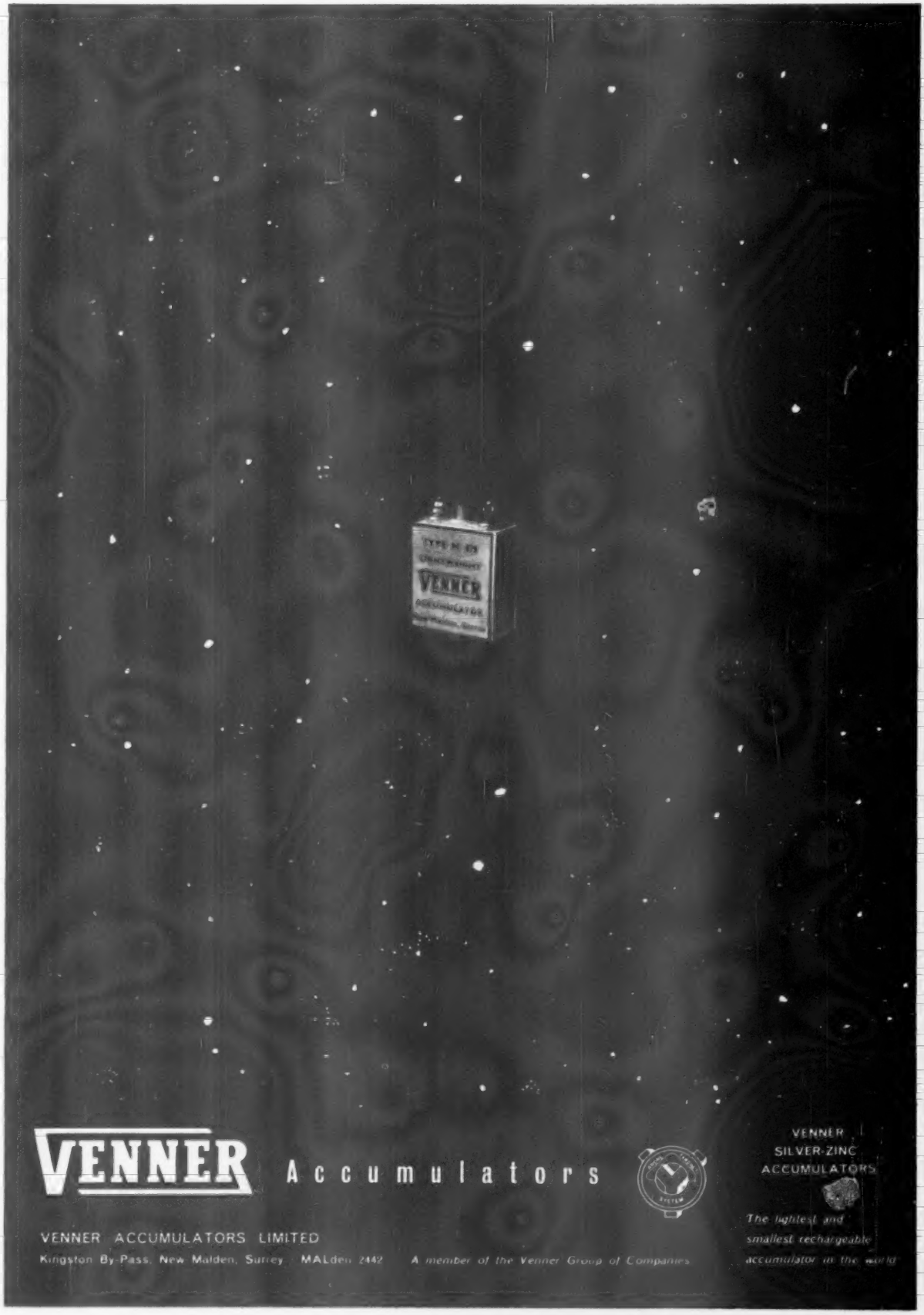
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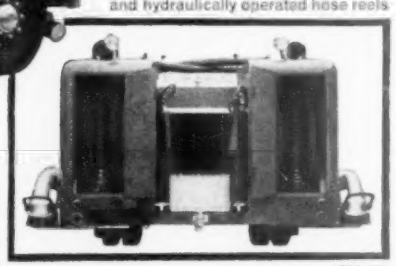

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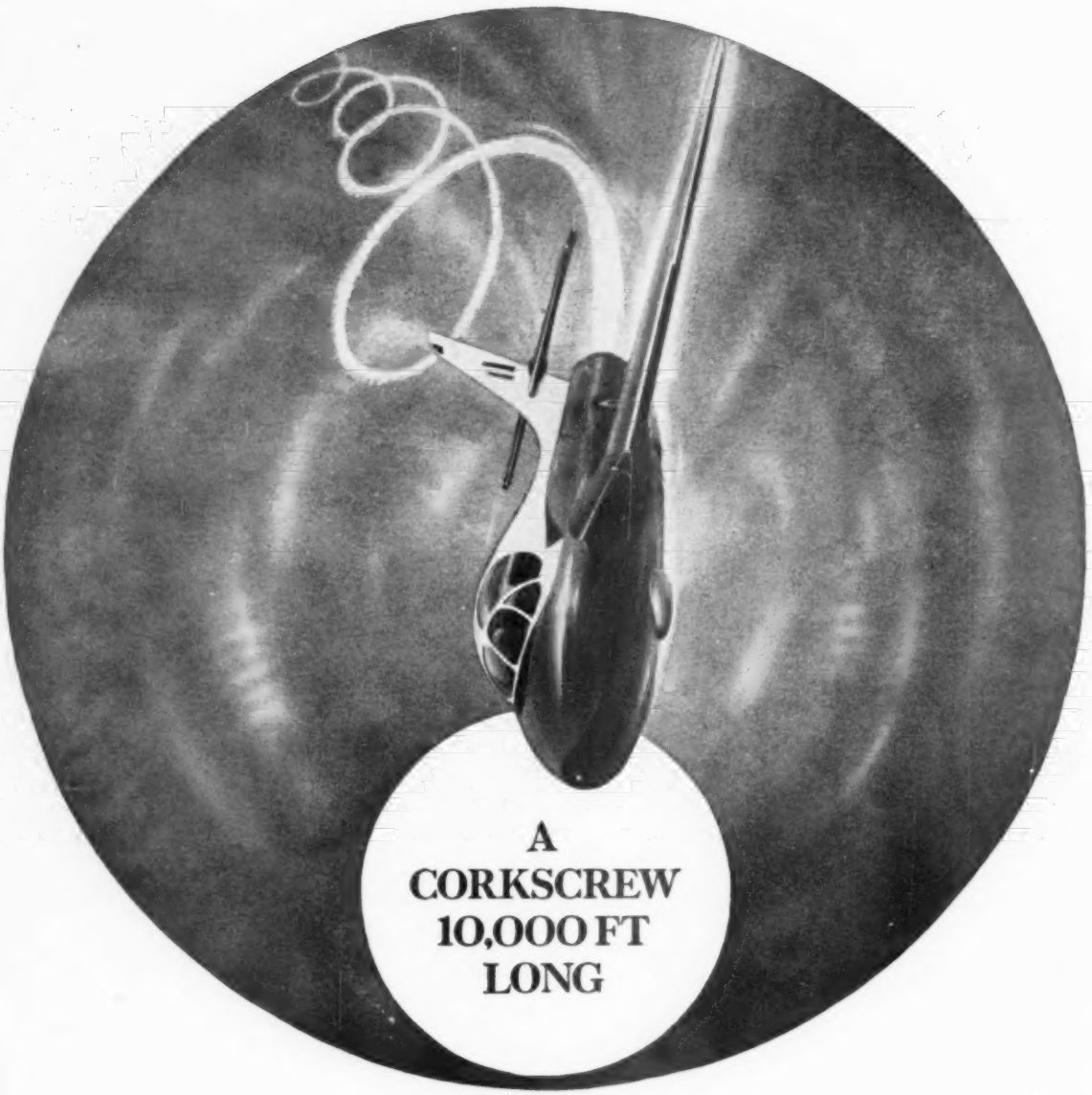

15,000 feet above the Farnborough crowd, test pilot Bill Bedford threw the red Hunter two-seater trainer into a spin. Falling 10,000 feet in fifty seconds he corkscrewed 12, 13, 14 times — then regained perfect control.

"You saw for yourself" he said, "how hard it was to get into a spin, you have to be really brutal. But in training, we have got to be able to teach pilots how to spin and how to get out of a spin — just in case."

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THE AEROPLANE and ASTRONAUTICS

VOLUME 100 NUMBER 2571 JANUARY 27, 1961

Space—Whither the U.K.?

On one aspect of space activity there seems to be some general agreement, namely that the United Kingdom cannot go it alone. We take leave to doubt this; we believe it should—and could. However, the fact is not to be concealed that whereas the scientists of this country did much to establish British leadership in nuclear fission and in radar and Whittle to pioneer gas turbine development, British scientists have not made a noticeable impression in the field of space technology. The drive to achieve in this vital field of human activity has come from the British Interplanetary Society. In this issue a leading member of this body examines the position as it appears in the U.K. today, and goes on to argue that there is no alternative except to collaborate, so far as we may obtain permission to do so, with the United States. A deplorable leader in *The Times* of Jan. 11, "A Dubious Project," carried the argument even further; fortunately the vigorous Mr. Woodrow Wyatt took up the cudgels in a letter which, published on Jan. 16, stigmatized the article as an excellent example of the lack of competitive thrust, now apparent in the national mood, which curbs the expansion of industry and exports.

Let us make it quite clear that, in giving Mr. Greenwood space to air his views, we do it so that they be combated. We uncompromisingly support the statement of Mr. Wyatt to *The Times* that "to advocate as you do that we should not only regard advances in space technology as beyond our own means, but beyond those of the combined resources of the Commonwealth and Europe as well is to propagate a defeatism which, as it spreads, will make us increasingly incapable of keeping our competitive position in the world—let alone enhancing it."

It is really extraordinary how complacently people regard the failure of this country to press on with its work on rockets and satellites. One would have thought that even the benefits of the Welfare State could not so blur the national vision as to obscure the facts of life on the export market. As the islands in our northern sea are not Pacific islands, it is necessary to work to live and the more we insist on the rights of all citizens to enjoy a life of leisure and mechanical aids to enjoyment the more essential it is to have a thrusting, aggressive policy in export markets.

Such enterprise must be backed by the technical ability to manufacture superior products. In the past such progress has stemmed from aeronautical work; in the future it is going to come from astronautics. Already, the dividends arising from miniaturization necessitated by missile requirements are plain for all to see.

And if as a country we have not the determination to tackle the task unaided, we had best tackle it with the aid of the Commonwealth and our friends in Europe. But there must be no more delay.

Kerosene—Those Vital Seconds

In this issue we publish Mr. J. W. Rickard's answer (see p. 82) to the points made by Mr. J. T. Dyment in a recent statement (Jan. 6). Any need to comment seems to have been eliminated by the outcome of the accident to the DC-8 of Aeronaves de Mexico (see p. 86).

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Matters of Moment

Vertical-lift Starfighter

LOCKHEED have already test-flown an F-104 Starfighter with large wing-tip pods designed to carry jet-lift engines. Two separate sources have independently reported that this aircraft has been flown at supersonic speed. It is not clear whether jet-lift engines were actually installed. More probably pods of representative size were fitted to investigate their effect on the performance of the aircraft.

The Lockheed proposal for a VTOL version of the F-104 depends on installing large wing-tip pods, each carrying seven jet-lift engines and additional fuel. In hovering flight the aircraft would be stabilized by using differential engine thrust.

This Lockheed proposal must be aimed at NATO decisions about a future VTOL strike aircraft. Germany, Italy, Belgium and Holland are committed to a large production programme on the Starfighter. If this aircraft can be developed into an effective VTOL type, it could well be favoured because they have already tooled up for Starfighter production. But it is unlikely that a VTOL Starfighter will be as effective a VTOL strike aircraft as one designed for this role from the very start.

Clearly competition is getting ever hotter in the NATO VTOL field. Six nations have designs competing for adoption and a long battle seems likely before any single type is chosen, if in fact this ever happens.

M.P.F. from the Gliding Viewpoint

"DOWN to earth" and "the most practical lecture we have yet heard" were the descriptions applied by Mr. B. S. Shenstone, the chairman, to Mr. Lorne Welch's talk to the Man-Powered Aircraft Group on "Gliding and Man-powered Flight" at the Royal Aeronautical Society on Jan. 20.

Mr. Welch's ideas were almost literally "down to earth," for he could see no point in flying a man-powered aircraft more than a few feet above the ground. Even with 20% surplus power, the machine would only climb about 2 in. per sec.; and at higher levels it could encounter turbulence, which would demand an increase in the structure weight.

But, above all, at greater heights the advantage of "ground effect" would be lost. The reduction in drag due to this effect depends on the height of the wing-tips above the ground. If this height is 20 ft., drag is 84% of its normal value; at 10 ft., 68%, and at zero feet, 45%. The important question is, therefore, how near the ground can you fly? A good sailplane pilot can fly safely with his wing-tips 2 ft. from the ground, but Mr. Welch thought the distance need not be much more than 1 ft.

The most important point the lecturer made was that, although there is sufficient knowledge now to design and build a man-powered aircraft, many of the problems of flying it have still to be tackled.

Are controls really necessary? The ideal would be to do without them. Anyway, since the rudder control is rarely needed, it might be worked by a sideways movement of the knees while pedalling, leaving the other two controls to be worked by hand as usual. If there are two occupants, each could drive a separate propeller, and steering could be done by one pedalling harder than the other. Nicholas Goodhart has suggested a pod at each wing-tip, each containing a working pilot who would be responsible for keeping his own end up at just the right distance from the ground, and at the correct speed.

Should the testing be done by a glider pilot or an athlete? They are "a most unusual combination" in the same person. Mr. Welch plumped for the glider pilot, who has at least had experience of the "rhythm," as he called it, of flying a rather similar machine. Even then, if anything went wrong on the first test flight, so many factors would be involved that it might be impossible to sort out which was responsible for the trouble. Launching the machine from a height would give more time to find things out, but again the machine would then need a higher safety factor and therefore more weight.

In conclusion, Mr. Welch urged that the question of flying such a machine should be considered at an early stage of the design, because no one yet knows whether a man is really capable of controlling it while "pedalling it like mad."—A.E.S.

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RECOGNITION EXPERT.—Mr. E. G. A. Wilton looks on as Cdt. Sgt. P. M. Westwood receives the Air Pictorial Trophy from Mr. J. Lankester Parker after the All-England Aircraft Recognition Competition on Jan. 21. Results on page 85.

Italy's First Space Research Experiment

ITALY has made a most successful start to a programme of space research, which is being conducted jointly by the Ministry of Defence and the National Council of Research. The vehicle used was a Nike-Cajun rocket, supplied by NASA, which was launched on Jan. 12 from the rocket range at Perdasdefogu in Sardinia. The second stage of the rocket reached a height of 170 km. and, in response to a command from the ground, released a stream of sodium vapour from an altitude of 90 km. to the top of its trajectory. The launching took place shortly before sunset in a clear sky. The sodium vapour was clearly visible to the naked eye and was successfully photographed by seven different observing stations situated in Sardinia and on the Italian mainland.

The purpose of the experiment was to obtain data of the density, temperatures, and coefficient of diffusion of the outer atmosphere, and of wind velocities. The detailed research work involved in this experiment and those which are to follow is being undertaken by the University of Rome, under the direction of Professor Luigi Broglio.

Although there is nothing new in the launching of a Nike-Cajun rocket, the Italian authorities are particularly pleased with the success of their first venture into space research. The efficient functioning of the launching pad, cinetheodolites and radars at Perdasdefogu, as well as the newly trained Italian Air Force personnel, has been proved in practice. There is considerable confidence that the planned programme of launchings over the next few months will be successfully achieved. The Italians also claim that this is the first experiment in space research, on this scale, to have been conducted in Europe.—T.D.C.

ARMY'S FRENCH PURCHASE.—Another demonstration of Franco-British co-operation has been the acquisition for the Army Air Corps of a further 12 Alouette 2 helicopters. Powered by the 400 h.p. Turboméca Artouste 2 the Alouette 2 carries five. Five have already been bought for the A.A.C. (See also p. 94)

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COMMAND OCCASION.—The Rt. Hon. Julian Amery, Secretary of State for Air, was entertained to dinner at Fighter Command, H.Q., Bentley Priory on Jan. 23. Left to right here are: Air Marshal Sir Hector McGregor, A.O.C.-in-C., Fighter Command; Air Commandant A. Stephens, Commandant W.R.A.F.; the Rt. Hon. Julian Amery; Air Chief Marshal Sir Thomas Pike, C.A.S.; Sir Maurice Dean, Permanent Under Secretary of State for Air; Air Marshal Sir Kenneth Cross, A.O.C.-in-C. Bomber Command.

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Ministry of Aviation Appointment

MR. D. E. MORRIS, M.B.E., chief superintendent of the Royal Aircraft Establishment at Bedford, has been appointed director-general of aircraft research and development (R.A.F.) in succession to Mr. L. Boddington, C.B.E., who has resigned from the public service.

Mr. Morris, 45, was born in Penrhyndeudraeth, Merionethshire and obtained a Bachelor of Science degree from the University of Wales in 1936, with First Class Honours in Mathematics. After joining the R.A.E. in 1938 he worked for 11 years in the Aero Flight Section. In 1955 he was appointed chief superintendent A. and A.E.E., Boscombe Down, and in 1959 to his present post at Bedford.

Mr. Morris will take up his new duties early next month.

VC10s for Ghana

AS we go to press, the British Aircraft Corporation has announced the receipt of an order for three VC10s from the Ghana Government. To be delivered in 1964, they will further strengthen Ghana Airways' bid for pre-eminence among African airlines.

Those Viscount Cracks

FURTHER cases of corrosion cracking in Viscount wing spar booms have been discovered following Vickers recommendation to operators that all wing joints should be inspected (see our issue for Jan. 13). In addition to the urgent action recommended in respect of 86 early Viscount 700s (those with DTD363 lower spar booms), inspection was recommended for all Viscounts within the next six months.

In the light of the latter advice, Indian Airlines inspected a Viscount which was undergoing a major overhaul and found cracks in a top boom. The decision to ground the fleet of 10 Viscounts until all had been inspected was taken, but they were quickly returned to service.

Cracks in the top boom are not critical as this member is not heavily loaded in flight. It is likely that a limited amount of cracking in the top booms will be accepted, subject to periodic inspection, but the greater risk inherent in cracked lower booms requires their replacement.

A Wealth of Advice

THE formation of local committees to advise the Air Transport Licensing Board is discussed on p. 87, where the constitution of the first of these, the Scottish Advisory Committee for Civil Aviation, is announced. Since going to press with that page, the members of the Welsh and Northern Ireland committees have also been announced.

Sir Miles Thomas, D.F.C., will chair the 14-man Welsh committee, and Wg. Cdr. R. C. Preston, O.B.E., A.F.C., will head a similar-sized committee for Northern Ireland. Sir Miles has been chairman of the Development Corporation for Wales since 1958 and was, of course, chairman of B.O.A.C. from 1949 to 1956. He is chairman of Monsanto Chemicals. Wg. Cdr. Preston was a member of the Northern Ireland Advisory Council for Civil Aviation which the new committee replaces. He was Officer Commanding the Northern Ireland Air Training Corps for eight years and is a founder member and Liveryman of the Guild of Air Pilots.

As explained on p. 87, the duty of the committees is to advise the A.T.L.B. on the exercise of its functions in relation to local circumstances.

United Kingdom Secondary Radar

AN experimental secondary surveillance radar system is to be introduced shortly to serve the Southern Air Traffic Control Centre at London Airport. This experimental service will, in due course, become part of the normal operational facilities of the Southern Centre and similar facilities will be deployed to cover other areas of the U.K. airspace.

During the experimental stage, aircraft wishing to use the service will need to carry a two-pulse side-lobe suppression transponder, such as the Cossor Type SSR.1251, operating in accordance with the provision of Annex 10 to the ICAO Convention.

When the secondary radar service becomes fully operational it will be mandatory for aircraft to carry a transponder in order to operate in certain areas of U.K. airspace above a minimum height which will be specified. Initially, this minimum height may be of the order of 25,000 ft., but subsequently the level will be lowered progressively as and when ground and aircraft equipment programmes permit.

Civil aircraft transponders will be required, as during the experimental period, to provide two-pulse side-lobe suppression facilities.

Research Workers Wanted

BY the age of 42 more than half the scientists now being recruited by the Ministry of Aviation can expect to earn £3,000 a year or more. Outstanding men could be getting £4,000 a year, according to "Research Careers in the Ministry of Aviation," a new booklet issued by the Ministry's information branch. It outlines the wide variety of scientific work open to graduates at Ministry establishments and gives details of their conditions of service.

Airpass and the Mirage

FOLLOWING the initial Australian decision to buy 30 M=2 Dassault Mirage IIICs, and the Swiss contract for 100 similar aircraft, strenuous efforts are being made by Ferranti, Ltd., to secure orders to supply their fire-control equipment. The Airpass II fire-control radar, offered as an alternative to the French C.S.F. Cyrano equipment, is claimed to provide more operational features for multi-mission capability for half the weight, and to be two-three years ahead of equivalent systems.

Airpass II in the R.A.A.F. and Swiss Air Force Mirages would be worth from £5-10 million to Ferranti. A decision on the operational equipment for the Australian and Swiss Mirages is expected later this year. In the meantime, further visits

Matters of Moment . . . .

from technical missions to evaluate Airpass II are expected at Ferranti's Edinburgh factory.

The divisional manager of the electronics and inertial systems section of Ferranti, Mr. Mallinson Powley, said last week that the lightweight monopulse radar which was the heart of Airpass was first disclosed to a German mission in May, 1957. A French Air Ministry technical commission visited Edinburgh in October, 1957, as prospective customers for Airpass I, which is installed in the R.A.F. Lightning fighters, and has completed more than 1,200 hr. of flight operation. Development of the rival French radar system began immediately after that visit, according to Mr. Powley.

In 1958, Ferranti designed and proposed Airpass II, which used the same basic radar and fire-control equipment, but was given dual facilities for air-to-air and air-to-surface functions. This system proved extremely popular in connection with procurement (for the Lockheed F-104G) by Belgium and Holland, and was shown to another French mission on Oct. 7, 1959. Proposals for a comparable French development were, according to Mr. Powley, made exactly one month after that.

Ferranti has collaborated with G. A. M. Dassault in developing the Airpass II installation for export in the Mirage, but so far the co-operation has been at company rather than Government level. The collaboration began in 1958 and became very active in the latter part of 1959, when Holland and Belgium were offered the Mirage III with Airpass II, since the Cyrano I radar was not acceptable. European acceptance of the F-104G rather than the Mirage was apparently for political and economic, rather than technical, reasons.

Although Airpass II has, so far as is known, not yet flown, it is already installed in Ferranti's research Meteor all-weather fighter, and is said to be considerably farther ahead in development than comparable French or American equipment. The Autonetics Super Nasarr has been specified for the F-104G. About 75 % of Airpass II is similar to the Mk. I equipment, and although about two years would be necessary to get the British equipment in service on the Mirage, this would enable the procurement time-scales to be met.

British interest in Airpass II is limited by the fact that this is dual-purpose equipment, and the R.A.F. is traditionally wedded to single-mission interceptors or bombers. The TSR-2 is typical in being a special purpose aircraft, while the P.1127 conforms to very different requirements.

The monopulse system used in Airpass II is common among ground radar equipment, but Ferranti's is the first successful application in high-powered, lightweight, airborne equipment. The monopulse system is primarily distinguished by the use of electronic, rather than mechanical, lobe-splitting for the different modes. In addition to the Mirage orders already announced, Israel is reportedly interested in 40 of these fighters.

Kerosene—Mr. J. W. Rickard Answers Mr. Dyment

MR. DYMENT (THE AEROPLANE AND ASTRONAUTICS, Jan. 6, 1961) has now publicly stated the case for JP.4 fuel. My own reaction to his statement, taken paragraph by paragraph, is as follows:—

Paras. 1 and 2. I agree.

Para. 3. Surprising as it may seem, Mr. Dyment has not taken the trouble to read Lord Brabazon's several statements. What we demonstrated before the "eight million sweaty night caps" was not just that the flame of a match was sufficient to touch-off the JP.4, but that the rate of flamespread was so very much higher across the JP.4 than across the kerosene. It is this fundamental difference which gives the occupants time to escape from the crash of a kerosene-fuelled aircraft.

Para. 4. Mr. Dyment is drawing an incorrect conclusion from the NACA tests (Ref. 2) (I presume Mr. Dyment is referring to the formation of fuel mist when he talks about fuel "splashing"). Agreed, if an aircraft after crashing is *enveloped* in fuel mist and this mist ignites, there will be a disastrous fire from which no one can hope to escape, regardless of the type of fuel. But the NACA tests were so staged as to produce deliberately the maximum amount of mist. This was done by breaching the tank leading edges with conveniently placed stanchions so as to leave large *forward facing* orifices through which fuel was projected under the impetus of deceleration. Certainly this can occur in a real crash, but Mr. Dyment is quite wrong to imply that it is typical of the majority of survivable crashes. How otherwise can be explained away the fact that in at least five of the accidents listed in Ref. 1 (to which must be added the Electra at La Guardia), aircraft struck the ground, sometimes with violence, and caught fire but that still substantial numbers of people were able to walk out?

Also, if ignition does not occur immediately, a quite moderate wind can render a mist innocuous within a few seconds, whereas the danger from spontaneous ignition and electrical arcing remains for a considerable time.

Para. 5. While spontaneous ignition, and ignition from burning engine and hydraulic oils are probably the commonest causes of fuel fires in a crash, what justification has Mr. Dyment for minimizing the dangers of electrical arcing by saying that "the electrical system goes out in the crash"? Crash switches, when fitted, do not always have the opportunity to work, and as most accidents are unpremeditated, manual switching out of the electrics is rarely possible. Sparking from abrasion on concrete surfaces is also prevalent in some crashes; the Comet landing on its wheelless undercarriage in Madrid gave a spectacular demonstration of this.

Para. 6. Congratulations to T.C.A. for pioneering a fire-resistant hydraulic fluid.

Para. 7. It is correct to state that the spontaneous ignition temperature of JP.4 is higher than that of kerosene, but every authority which has tested the two fuels has come up with a different answer as to the magnitude of the difference. Mr. Dyment, in order to make his case, quotes a figure of 222° C. (400° F.), whereas another authority puts the difference as low as 3.5° C. (6° F.) (Ref. 4). In Ref. 1 I quoted the results of an investigation carried out by the Douglas Company (Ref. 5). This showed a difference of 100° C. (180° F.) in favour of JP.4 under specified conditions. I believe this to be the very maximum order of difference to be found in a powerplant.

In any case, as Mr. Dyment well knows, the NACA tests showed that engine surface temperatures in a crash were high enough to ignite all fuels in current use. In the tests with jet-engined aircraft described in Ref. 3, the JP.4 fuel caught fire without the slightest difficulty.

Para. 8. Great attention must be paid in design to ensure that leaking inflammable fluids are drained overboard as easily as possible. It cannot be concluded that leaking kerosene is more likely to cause a fire than JP.4. If the latter fuel is let loose in quantity, only its lighter ends will evaporate; the kerosene-like residue will be left behind to "crawl." If the evaporated light ends come into contact with an ignition source, they may well cause something worse than a straightforward fire, namely, an explosion.

Which Vulcan is Mr. Dyment referring to?

Para. 9. Restarting an engine in flight can generally be accomplished a few seconds earlier with JP.4 than with kerosene, but this cannot make the slightest difference to the safety of the aircraft. Mr. Dyment has gone out of his way to suggest that restarting may not be possible at all with kerosene. So far as British engines are concerned, this is mischievous nonsense. One does hear, however, that some non-British engines are reluctant to restart at altitude with kerosene, but I have yet to learn that this has jeopardized safety, although it may well cause inconvenience. What these engines need, of course, is further development and not JP.4.

Para. 10. In stating that kerosene burns at a hotter temperature than JP.4, Mr. Dyment is presumably referring to flame radiation characteristics. Again, British engines are not troubled by this, and I do not believe that non-British engines are troubled to the extent of their safety being jeopardized.

Para. 11. All fuels, and kerosene in particular, need most careful filtration. This is being successfully done wherever turbine-powered aircraft operate.

Para 12. Sir William Hildred says that JP.4 is less explosive than aviation gasoline. This is not true. Because JP.4 is less volatile, it requires a higher temperature range to make it explosive, and this range is of such an order that it will be encountered more frequently than that required for a gasoline explosion. This does not mean that gasoline is safe (the loss of a T.W.A. Constellation in 1959 has been attributed to fuel tank explosion) but only that explosions are more liable to occur with JP.4.

Also, extra special precautions need to be taken during the ground handling and storage of JP.4 (Ref. 4). From the crash standpoint, JP.4 fuel/air mixtures in a tank will often be in the explosive range and near stoichiometric, particularly during landing. This means there will be a distinct possibility of a violent explosion the moment fire breaks out: this in addition

(Continued on page 104)

Man from the Ministry

A MINISTER, it might be said, is only as good as his advisers. Government decisions on policies and courses of action are largely guided by the information and counsels given to Ministers by their secretarial staffs who therefore carry an immense responsibility.

Among this hierarchy of Civil Servants, an arduous responsibility has been shouldered in recent years by Mr. Denis W. G. L. Haviland, C.B., Deputy Secretary (C) in the Ministry of Aviation. His was the task of gathering the facts and the views and the possibilities which, when sorted out and assessed, formed the basis on which his Minister, Mr. Duncan Sandys, implemented the policy of regrouping the major part of the aircraft industry. Now, under the new Minister, Mr. Peter Thorneycroft, he has a part in moulding the destiny of Blue Streak, the P.1127, our supersonic airliner project, and other products on which the prosperity of the industry and its quarter of a million employees very much depends.

In spite of possessing a wonder name like D. Haviland, he is not a man of aviation although one suspects that after nine years of contact with our inspiriting, maddening business, some of it must have rubbed off, and at the very least we hope that he will be sorry when he is posted away from it. The Civil Service, like the Fighting Services, lays down principles and methods which can be applied to most fields of administration and a lot of its members, like Ministers and Parliamentary Secretaries, are liable to be moved around, though less frequently.

Mr. Haviland was an administrator with the L.M.S. Railway before the War, then was commissioned in the Royal Engineers to do a similar job during 1940-46. After hanging up his Colonel's uniform he worked in the Control Office for Germany and Austria, then went to the Foreign Office and the Imperial Defence College and so, in 1951, to the Ministry of Supply. There, as an Assistant Secretary, he dealt for three years with the intricacies of electronics. Promotion to Under Secretary (Air) in 1953 brought him into the airframe orbit and eventually plunged him into the changing world of aeronautics.

As you see, eleven years of surface transport administration did not result in a Ministry post dealing with air transport but with the manufacturing industry. Administration is administration—the hardware, the end product, is almost incidental. The Ministry is loaded with technical and other experts whose

specialized knowledge is available to add to all the other information which a Deputy Secretary (a 1959 promotion) must formulate so that the Minister can examine it in the round. When the ultimate decisions have been made, the D.S. sees to it that they are administered.

The work calls for frequent meetings with company directors and executives and with the S.B.A.C. and other trade organizations and interested parties. Lately, the possibility of international collaboration in the fields of astronautics and supersonic air travel, as well as the political aspects of foreign trade and interchange of aviation products, often take Denis Haviland to the Continent. It was during a visit to France with Mr. Aubrey Jones, then the Minister of Supply, that a French Minister complimented him on his splendid Comet airliner and asked him how his company was getting on. Probably rather trying for an impartial Civil Servant.—WREN.

Effectiveness of the Deterrent

NUCLEAR deterrents are usually discussed in general and often emotional terms. It is conducive to clearer thinking to read an article which examines their effectiveness in detail and attempts to establish how many targets they would destroy following a retaliatory attack by the West. Mr. Frederic Jones has made such a survey.*

For the purpose of discussion he assumes that the British strategic deterrent is made up today of 200 V-bombers and 60 Thor IRBMs, and that the U.S. has 1,700 aircraft (500 B-52s and 1,200 B-47s) and 15 Atlas ICBMs. In the event of a surprise attack, he assumes that 5% of the V-bombers could get off the ground within the limited warning time available and that 5% of the force would be airborne at the time. Thus only 10% of the V-bombers, or 20, would be able to attack and, assuring a kill probability of 75%, this means that maybe only five would reach their targets. It is considered that 12 of the Thors could be launched before those remaining on the ground were hit by enemy attack.

There would be a greater warning time for the U.S. weapons. Working on an assumption similar to those for the British weapons, it is assumed that in all 130 targets might be destroyed, of which seven would be hit by V-bombers and twelve by R.A.F. Thors.

In fact, Mr. Jones' assumptions on the number of V-bombers available and the Thors that would be launched are probably optimistic. But this does not affect his main argument, which is that Britain's deterrent would destroy only about 15% of the targets hit by Western missiles and aircraft.

To improve the effectiveness of the British deterrent, Mr. Jones argues that the Fylingdales early-warning base should be completed immediately on a cost-no-object basis. At least 10% of V-bombers should be kept airborne at all times and at least 30% more at four minutes' notice.

Bomber Command should adopt the Quail counter-measures missiles which, it is claimed, in effect doubles the life of an aircraft. Mr. Jones argues that beyond 1966 only a Polaris submarine seems likely to have any survival ability, and Britain should build these submarines at the rate of one a year to give a reasonable force by 1966.

Other points made are that warning is very important and that Britain should contribute towards an early-warning satellite network. At the very least we must have the fullest information and monitoring facilities from U.S. satellites.

* *Crossbow*, New Year, 1961, 2s. 6d. Bow Publications, Ltd., 60 Berners Street, W.1.

Royalties on Sales

ACCORDING to the Society of British Aircraft Constructors, between 1951 and 1959 the Government received back from the aircraft industry about 24% of the money provided for non-military research and development.

This is based on an official statement that in the eight years ended March, 1959, Government payments to the industry for research and development of airframes and aero-engines had amounted to £430 million, of which the overwhelming majority had been for military aircraft for the British Services. No royalty was expected on these, although the prices were lower than if the industry itself had paid for research and development.

During the same period about £24 million was received from the industry in royalties on sales of aircraft developed with Government assistance. In 1959, royalties on overseas sales amounted to £7.5 million.

Considering aero-engines alone, the Government paid the industry approximately £289 million for research and development between April, 1950, and March, 1960, and received in royalties about £17 million.

On the basis of ministerial statements the S.B.A.C. suggests that more than three-quarters of the sums quoted were devoted to military research and development. Thus all but about £70 million of the £289 million for aero-engines and £100 million of the £430 million for aircraft and aero-engines were spent on U.K. defence. The royalties in each case come to about 24% of the non-military R. and D. expenditure, although this probably gives a somewhat false impression of the return on Government support for civil development because the royalties doubtless include payments covering the export of military aircraft such as the Hunter and Canberra.

In future there will be a greater need for Government backing of civil projects. In 1954/55 military production was 79% of the British industry's output, compared with 54% in 1959/60. The latest comparable U.S. figure is 83%.

Aviation News in General

ORPHEUS ORDER.—A new order for Orpheus 805 turbojets has been received by Bristol Siddeley from the Japanese Defence Agency. This is the second order in 14 months for Orpheus engines to power Fuji T1F-2 trainers.

STANDING PATROLS.—U.S.A.F. Strategic Air Command is now keeping a number of B-52 bombers in the air at all times. According to its commander, Gen. Thomas Power, this will "reduce to a minimum the time required by S.A.C. bombers to respond to any hostile action by an aggressor." All combat-ready B-52 crews are taking part in airborne alert training flights. B-52s remain airborne for 24 hours and are flight-refuelled by KC-135s.

R.A.F. "AT HOME."—Because of the clash with the Paris Show, the R.A.E., Farnborough open days have now been put back a week to Jne. 9 and 10.

KATANGA AIR FORCE.—Six light aircraft were reported last week to have arrived from South Africa for the Katanga Air Force, which is believed to have about three Dakotas, four Doves, several Cessnas and two helicopters. There is some evidence that jet fighters are being sought from Western Europe.

R.A.F. RADAR.—Airfield surveillance radar for the R.A.F. has been ordered from Cossor Radar and Electronics, Ltd. The contract covers a substantial number of static Cossor CR.787 installations originally developed as a private venture by the company. It follows an earlier contract for a smaller number of the same equipment in mobile form. Much of the static installation will consist of duplicated S-band transmitter-receivers and radar displays.

POLARIS PATROL.—"George Washington," the first U.S. Polaris submarine, returned to New London, Connecticut, on Jan. 21 at the end of its initial patrol, which began on Oct. 27.

VC10 HANGAR.—Work will begin this year on enlarging the wing hangar at the B.O.A.C. maintenance base to accommodate VC10s. The depth of the hangar will be increased by 70 ft. and the new positions will be taller to accommodate the fin and tailplane.

MORE SPACE VISITS.—Mr. Peter Thorneycroft, Minister of Aviation, visited Rome on Jan. 18, and Berne on Jan. 22, for talks with Italian and Swiss Ministers on the proposal to develop a space launcher "for scientific and commercial purposes in collaboration with European and Commonwealth countries."

T63-POWERED.—The Bell HUL-1M utility helicopter is the first aircraft to be powered by the 250-s.h.p. Allison T63 turboshaft engine. This helicopter is now being flight-tested at the Bell Fort Worth plant. The HUL-1M is basically the HUL-1 Bell 47J helicopter modified for U.S. Navy trials with the T63.

In Rome he is reported to have said that Britain would contribute free all her civil information on Blue Streak, worth about £60 million. Thereafter Britain would share the costs, with each member country subscribing according to its national product or wealth. Italy is interested in the project and will join in the talks to be held at Strasbourg.

MORE HUSTLING.—Continuing its attempts on the 1,000-km. closed-circuit records for absolute speed, and speed with payloads of 1,000 and 2,000 kg., a USAF Convair B-58 achieved an average speed of 1,284.73 m.p.h. on Jan. 14, (84 m.p.h. faster than the figure set up by the B-58 for three records over 2,000 km.).

LAOS LOSS.—One, and possibly two, of the four North American T-6 armed trainers recently presented by the U.S. to Laotian Army Aviation, has been shot down by Pathet Lao forces. Six more T-6s were expected in Laos from the U.S. within the next week, but reports that Republic F-84s were being transferred have been denied by the State Department.

LUNAR VEHICLE.—NASA has selected Hughes Aircraft Co. for contract negotiations to build a soft-landing lunar vehicle known as Surveyor. It will soft land 750 lb. on the moon, more than 200 lb. of which will be instruments. Plans call for seven of these vehicles to be launched from Cape Canaveral between 1963 and 1966 by Atlas Centaur rockets.

DRONE CANCELLATION.—The U.S. Army has cancelled further development of the Republic SD-4 surveillance drone. £12 million had been spent on this project in 2½ years.

BOEING PROSPECTS.—According to Mr. G. R. Sanborn, Boeing director of commercial sales, his company expects to sell more than 100 jet transports during 1961—mostly 720s and 727s. By 1970 Boeing expects to have sold 650 jet transports of all types and anticipates advanced versions of the 707 and 720 remaining in production until then at a rate of three to five a month.

AERODYNAMICS IN BELGIUM.—Graduate engineers and scientists from NATO countries are invited to apply for entry for a one-year diploma course at the Training Centre for Experimental Aerodynamics. The course, which is free, will be held from Oct. 2, 1961, until Jne. 30, 1962. Further details and application forms can be obtained from the Director of the Centre, 72 chaussée de Waterloo, Rhode-Saint-Genèse, Belgium.

LECTURE AT L.A.P.—For its lecture on Jan. 31 the West Middlesex group of the Institute of Transport will meet in the lecture theatre, Queen's Building, L.A.P. Central, at 18.30 hrs. Capt. G. A. Yarotski, general representative of Aeroflot in the U.K., will speak on "Air Transport in Russia Today" and will illustrate his talk with four films.

ALL ABOUT MET.—Starting on Thursday, Feb. 9, a course of six weekly lectures entitled "Stages in the Development of Modern Meteorology" has been organized by the department of extra-mural studies of London University. Lecturers are Messrs. F. H. Ludlam and G. B. Tucker of Imperial College. The meetings will be held in Huxley Building, Exhibition Road, S.W.7 (opposite Science Museum), and begin at 18.45 hrs. Entrance fee is 2s. per lecture or 10s. for the course.

Commercial Aviation Affairs

J.A.L. TO LONDON.—The first Japan Air Lines proving flight over the polar route from Tokyo to London will arrive on Feb. 10. Regular service on the route, with DC-8s, will begin on Jne. 1.

PACIFIC DECISION.—President Eisenhower, in one of his last official decisions, refused to approve C.A.B. recommendations to expand U.S. trans-pacific services by allowing both Pan American and Northwest to introduce new routes. Influenced presumably by the independent report by United Research Inc. (see our issue for Jan. 6) which was opposed to these new routes, the President recommended a re-examination of the case during the next few years.

DC-8 ORDER.—K.L.M. has increased its order for DC-8s to 13, of which six will be Series 50s with turbofan engines. The new aircraft will not be delivered until the spring of 1962. The total of Douglas DC-8s now on order is 157, of which 114 have been delivered.

ANSETT BUYS MANDATED.—The whole share capital of Mandated Air Lines, a local operator in Papua and New Guinea, has been purchased by Ansett Transport Industries for £A950,000. Ansett-A.N.A. proposes to add two Piaggio P-166s to the present fleet of nine DC-3s and six smaller aircraft.

B.O.A.C. DIRECTOR.—Mr. Kenneth H. Staple has been appointed to the board of B.O.A.C. for a period of three years from Jan. 18.

OCTOBER MOVEMENTS. — There was a 5% increase in air transport movements at U.K. airports in October 1960 compared with October 1959, and a 28% increase in the number of passengers. The amount of freight traffic increased by 10%. More than one third of all the movements (11,379 out of 29,588) were at London Airport, where the October increase was 10%.

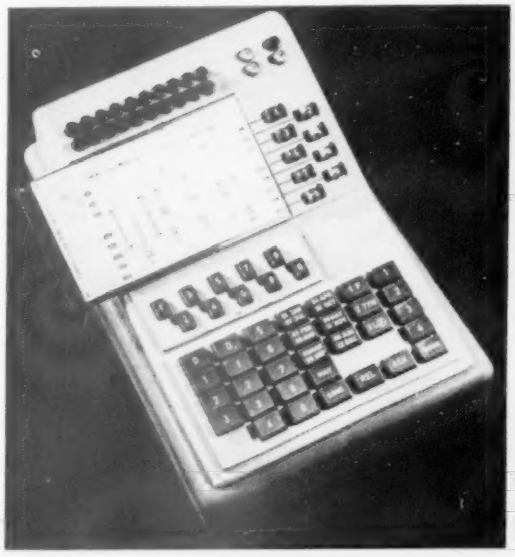
KUWAIT JET.—A United Arab Airlines Comet 4C became the first jet aircraft to land at Kuwait Airport on Jan. 12. The Comet operated from the existing 5,400 ft. runway but a new and larger airport with full facilities for jet operation is expected to be opened by the beginning of July.

NEW OPERATOR.—With the name Nordic Airways, a new charter company has been formed in Denmark to operate low-cost inclusive tours, and has purchased three DC-6s from United Air Lines. Another operator, Danish Air Charter, is reported to be seeking the use of two Viscounts in the coming summer season.

RIDDLE FIRSTS.—Riddle Airlines made its first operational flights with the Armstrong Whitworth Argosy and DC-7CF on Jan. 15. The DC-7 flew to Japan with high priority Government cargo and the Argosy made its first MATS Logair flight from Tinker Field. The company has seven of each type on order.

DUNDEE SERVICES.—Approval to operate services to Dundee has been granted to both Dan-Air (from Gatwick, Newcastle, Liverpool and the Isle of Man) and Overseas Aviation (from Prestwick).

IRISH SUMMER.—Irish International hopes to introduce regular services to Cork on Sept. 1 following the completion of the new airport. A daily Viscount service (Friendship in October) is planned between Cork and London, two Friendship services a week on the routes Cork—Cardiff—Bristol and Cork—Paris, and four services a week Cork—Dublin. Between Jly. 17 and Oct. 1, Aer Lingus plans to operate its Boeing 720s on the Dublin—London route.



S.A.S. RESERVATIONS.—Electronic interrogator sets installed by S.A.S. in their London ticket office are linked by telex to the central booking computer in Copenhagen. Space availability on ten alternative flights for a journey can be checked in seconds.

F.A.A. ADMINISTRATOR.—Following the resignation of Mr. Ellwood R. Quesada as administrator of the Federal Aviation Agency, his assistant, Mr. James T. Pyle, is acting administrator until the confirmation in office of Mr. Najeeb E. Halaby, the Los Angeles attorney and financier, designated as the new administrator by President Kennedy.

FIJI TO TONGA.—Fiji Airways started a regular fortnightly service between Fiji and Tonga on Jan. 26, using a de Havilland Heron.

GO-AHEAD FOR SCHIPHOL.—Agreement has been reached for the full development of Schiphol Airport, Amsterdam (see our issue of Jan. 15, 1960). The principal features of the programme will be the construction of an entirely new terminal building on the north side of the present airport area and the laying-down of one or more runways tangential to the new terminal. The Government is to contribute about £3.5 million; the balance of the cost will be covered by State-guaranteed loans. The terminal may be in use by 1964-65.

News About People

ENGLISH ELECTRIC.—Air Cdre. Strang Graham has retired from his position as commercial director of English Electric Aviation, aircraft division, and from the board of the company. Mr. A. G. Duguid has been appointed commercial manager of the company's aircraft division, responsible to the chief executive. Mr. J. W. Adderley, sales manager of the aircraft division, will now also be in charge of its London office.

Mr. A. G. Duguid (left), and Mr. J. W. Adderley.

MARCONI CHANGES.—With the regrouping of Marconi's aeronautical division the following staff changes have been made: Mr. F. Wheeler, formerly sales and contracts manager, becomes deputy manager; Mr. G. P. Parker becomes manager, engineering co-ordination; Mr. G. E. Beck, chief engineer (navigational aids) and Mr. L. R. Mullin, chief engineer (airborne communications). Other new appointments are Mr. J. H. Gill, service manager; Mr. E. Swinney, systems manager; Mr. B. J. Infield, sales manager, and Mr. C. A. R. Mackley, contracts manager. Dr. B. J. O'Kane is manager of the aeronautical division.

J.A.L. PRESIDENT.—Mr. Shizuma Matsuo has been appointed president of Japan Air Lines in succession to Mr. Seijiro Yanagita, who has been president since 1951. Mr. Matsuo has been vice-president since 1957 and is succeeded in this position by Mr. Kambu Ishikawa.

AIR FRANCE CHAIRMAN.—Upon the appointment of M. Max Hymans as honorary chairman of Air France, he has been succeeded as chairman by M. Joseph Roos.

EKCO DIRECTOR.—Mr. S. A. Clodd has been appointed to the board of E. K. Cole, Ltd. He was formerly works manager and executive director.

DOWN TO EARTH.—Until recently Fairey Aviation's senior test pilot at Ringway Airport, Manchester, Sqn. Ldr. David Masters has now been appointed special contracts representative to the Derritron Electronics Group.

SHOREHAM SUPERVISOR.—The Miles Organization has appointed Mr. J. W. C. Judge as pilot and aerodrome supervisor at Shoreham Airport. A former test pilot with Vickers-Armstrongs and Rolls-Royce, Mr. Judge holds the Queen's commendation for valuable service in the air.

RECOGNITION CHAMPIONS.—Results of the Aircraft Recognition Society's 14th All-England Contest held last Saturday are as follows: Hurricane Trophy for best team: R.O.C. 5/B.1 Enfield post (A. W. Hall, B. J. Tiley and R. Clark) with 100 out of possible 105 pt.; Heracles Trophy for best cadet team: 2121 (Abingdon) Sqn., A.T.C., 93 pt.; Britannia Trophy and Air Pictorial Trophy for highest individual score and highest cadet individual score respectively: Cdt. Sgt. P. M. Westwood, 2121 (Abingdon) Sqn., A.T.C., 35 pt.; Bloodhound Trophy for highest scoring Services team; R.Neth.A.F., 92 pt.; Fokker D.21 Trophy for highest scoring Service competitor: Flt. Lt. H. T. Ling, 34 pt.

SERVICE MANAGER.—Mr. D. G. S. Barrett becomes service manager of Dowty Rotol, Ltd., in succession to Mr. W. Spires who was recently appointed to the board of the company.

Air Transport

Independent Airlines—The Future

WRITING in our previous issue of the series of route applications made by British United Airlines to the A.T.L.B., we asked "Could the inclusion of the Trident and VC10 as possible future equipment in the B.U.A. applications be interpreted as a promise to buy British equipment if the Minister blesses the application?" The affirmative answer to this slightly rhetorical question was given a few hours before our issue was published, when B.U.A. circulated to M.P.s and others a statement of policy.

The statement—extracts from which are printed below—is important because it is the first since the 1960 mergers in the independent airline industry which attempts to set out where the new companies stand. It strikes an optimistic note for the future and outlines B.U.A.'s plans—subject to A.T.L.B./Ministerial approval of the route applications—to purchase four Vickers VC10s and five de Havilland Tridents, to build new flight sheds and offices at Gatwick and to construct a London terminal. The Civil Aviation (Licensing) Act, 1960, will, hopes B.U.A., "enable the independent companies for the first time to plan and invest for the future with some confidence."

The leaflet opens with a brief review of the status of independent operators under the 1946 and 1949 Civil Aviation Acts, which "gave little or no encouragement and were not such as to allow the planned development and investment on which any industry . . . must in the long term depend." Nevertheless, an important contribution to the national asset of a strong British civil aviation industry had been made by the private companies. The statement continues:—

"The post-war conditions . . . are now rapidly changing. Older and less costly types of aircraft do not now prove cheaper to run than modern types. It has already been demonstrated in practice that passengers, despite fare differentials, prefer to travel by the faster and up-to-date aircraft. In the intensely competitive conditions of today, these passengers must be attracted by any company which is to pay its way.

"By modern aircraft we mean jets. These call for a very large investment and, to be operated on an economic basis, must be kept fully occupied. A carefully planned route pattern, which will enable the jet aircraft to be operated as a closely knit fleet, is therefore a necessity. British United Airways has prepared such a plan and, thanks to the 1960 Act, has applied to the new Authority for licences to operate the necessary scheduled services.

"The total investment in British manufactured jet aircraft would be at least £17,500,000. In our view the minimum number of such aircraft which can be operated as an efficient fleet is four large jets (such as Vickers VC10 at a cost of £2,100,000 each exclusive of spares and other overheads) and five medium jets (such as D.H. Tridents) at £1,200,000 each.

Economic Minimum

"The size of investment planned, and the application to operate the scheduled services which are essential to sustain it, may appear epoch-making in the development of the independent sector of British air transport. We must emphasize that our plans are based on the minimum possible for economic operation under the competitive conditions of 1961.

"Though our plans are based on the smallest viable jet fleet, the application to operate a network of scheduled services will have no effect whatever on the existing scale of operations of B.E.A. and B.O.A.C. We are asking to be allowed to share in the general growth of air traffic. To carry out our plans in their entirety would involve no more than 20% of the Corporation's estimated traffic *growth* for the years 1961-65. The average annual increase in passenger traffic for the period has been assessed at 14% for the two Corporations."

The leaflet concludes with a note to the effect that British United Airways was formed by the amalgamation of 37 companies and gives some figures for 1960 operation: 17.8 million revenue miles flown; 631,030 passengers carried; 64,867 tons of freight; and 25,749 cars on the Channel Air Bridge. The fleet comprised 43 airliners and 47 helicopters.

An Abandoned Take-off Crash?

AT the time of going to press with this issue, it appears that the captain of Aeronaves de Mexico's DC-8 (XA-XAX), which crashed at New York International, Idlewild, had abandoned the take-off and had been braking and using reverse thrust. All but four—the two pilots, the flight engineer and purser in the flight compartment—of the 106 occupants survived and had left the aircraft before it was destroyed by fire.

The DC-8—which entered service in December with Aeronaves—had been taking off for Mexico City at about 01.25 hrs., G.M.T., on Jan. 20 (20.25 hrs., local, Jan. 19). Weather conditions were poor, with heavy snow and reduced visibility. With no survivors among the flight-deck crew it may be impossible to discover the reason why the take-off had been abandoned at such a comparatively late stage.

Good for B.E.A.

PROVISIONAL figures compiled by B.E.A. and given in the table below show that the Corporation had another good year in 1960. The average rate of passenger traffic growth, at 20%, was well above the World average (provisional ICAO figure) of 14%. The number of passengers carried, 3,800,000, was more than a million greater than the total for 1958.

During the year, the introduction of lower fares reduced the average revenue rate by about 5%, but a profit of some £1½ million was made. The profit in the 1960-61 financial year, which ends in March, will presumably be of the same order, compared with more than £2 million in the 1959-60 year.

B.E.A. has confirmed that it plans to operate up to four flights a day between London (Gatwick) and Paris during the coming summer, starting on Apr. 1. Reports that the airline was planning to introduce the "commander" concept of flight deck operation, with a captain overseeing two more junior pilots at the controls, have been denied. The concept is "one of a number of alternative operating policies which we have been studying for some time," Lord Douglas said last week, but "it is not true that this particular one is favoured by B.E.A. Nor is it our intention to make any such change in the foreseeable future."

TRAFFIC AND STAFF FIGURES, 1960
(Provisional estimates)

	Year ended Dec. 31, 1960	Year ended Dec. 31, 1959	Variation
Capacity ton miles offered	228,500,000	189,325,000	+20.7%
Load ton miles sold	151,500,000	126,444,000	+19.8%
Revenue load factor	66.3%	66.8%	−0.8%
Passengers carried	3,85[illegible],000	3,206,684	+20.6%
Passenger miles flown	1,352,000,000	1,130,514,000	+19.6%
Passenger load factor	67.5%	69.6%	−1.6%
Freight ton miles	16,590,000	13,852,100	+19.8%
Mail ton miles	4,180,000	4,009,800	+4.2%
Average number of employees	12,900	11,989	+7.6%
C.T.M. per employee	17,700	15,792	+12.1%

Cunard Eagle's Test Case

DETAILS are given in the second issue of *Civil Aviation Licensing Notices* (see our previous issue, p. 61) of an application from Cunard Eagle Airways, Ltd., for a licence to operate scheduled services across the North Atlantic. Judging by the series number given to this application by the Air Transport Licensing Board (A1000), it preceded the British United Airways applications discussed last week; certainly it raises equally profound issues and is no doubt designed to test the Minister's intentions in the same way. One has the feeling that on the outcome of these applications may depend the whole future attitude of Cunard Eagle and British United towards their participation in British air transport activities.

The Cunard Eagle application is for a service from London Airport and/or Manchester and/or Prestwick to any one or more of the following: Shannon, Keflavik, Gander, Montreal, Toronto, Boston, New York, Philadelphia, Baltimore, Washington, Detroit and Chicago, carrying all classes of passengers, cargo and mail. The licences are sought for a minimum period of 15 years from 1961. The basic service frequency would be one flight a day in each direction, but with lesser frequency initially and greater frequency later according to traffic demand. Britannias would be used at first and "later, jet aircraft (any

(*Continued on page 87*)

The new force in world aviation

The four member companies of British Aircraft Corporation have, since the war, constructed over 5,000 aircraft of all types. This number includes: **500 Four-Engined Turbine Airliners 900 Twin and Four Jet Bombers 1,700 Jet Fighters 1,100 Trainers** The aircraft now being built or developed within British Aircraft Corporation include VC10 and BAC-107 rear-engined jetliners, Vanguard and Viscount turbo-prop airliners, Canberra jet bombers, Lightning and TSR-2 supersonic military aircraft, the Jet Provost trainer, the T-188 all-steel supersonic research aircraft and a project study for a supersonic airliner * Guided weapons produced by British Aircraft Corporation include Bloodhound, Thunderbird, Blue Water and Vigilant * British Aircraft Corporation combines the aircraft and guided weapons interests of:

Bristol Aircraft Limited English Electric Aviation Limited
Vickers-Armstrongs (Aircraft) Limited Hunting Aircraft Limited

Together these famous companies have fashioned a powerful new force in world aviation. It is backed by great resources and by a confidence, an experience, and a knowledge unique to an organisation whose aircraft are today in service with 50 airlines and with the armed services of 28 nations.

TGA BAC2/1

D

TCA and BEA

AND THE VANGUARD

BEA

British European Airways who pioneered Vickers' Viscount travel and is now introducing the magnificent new Vanguard, has been able to lead the world in fare reductions. Cuts of up to 40% with an average reduction of 25% have been made possible by turbo-prop economy.

Mr Gordon McGregor, President of TCA, has this to say:

'The revision of TCA's fares is directly associated with the Company's plans for an all-turbine fleet in 1961. The lower unit operating costs anticipated from the Vanguard were a basic factor in the calculation of the new fare structure. TCA's highly satisfactory experience with the Viscount gives promise that its larger turbo-prop stable-mate, the Vanguard, will have an equally favourable impact upon air transport economies.'

CUT TRAVEL COSTS

TCA

Leaders of Viscount turbo-prop travel in North America, Trans-Canada Air Lines announces its lowest-ever fare structure. TCA's new Economy fares between Canada and the USA and its Excursion fares within Canada, are the lowest in the Airline's history. TCA Vanguards enter service on 1st February.

IS A BASIC FACTOR

TGA BVA13

VICKERS VANGUARD

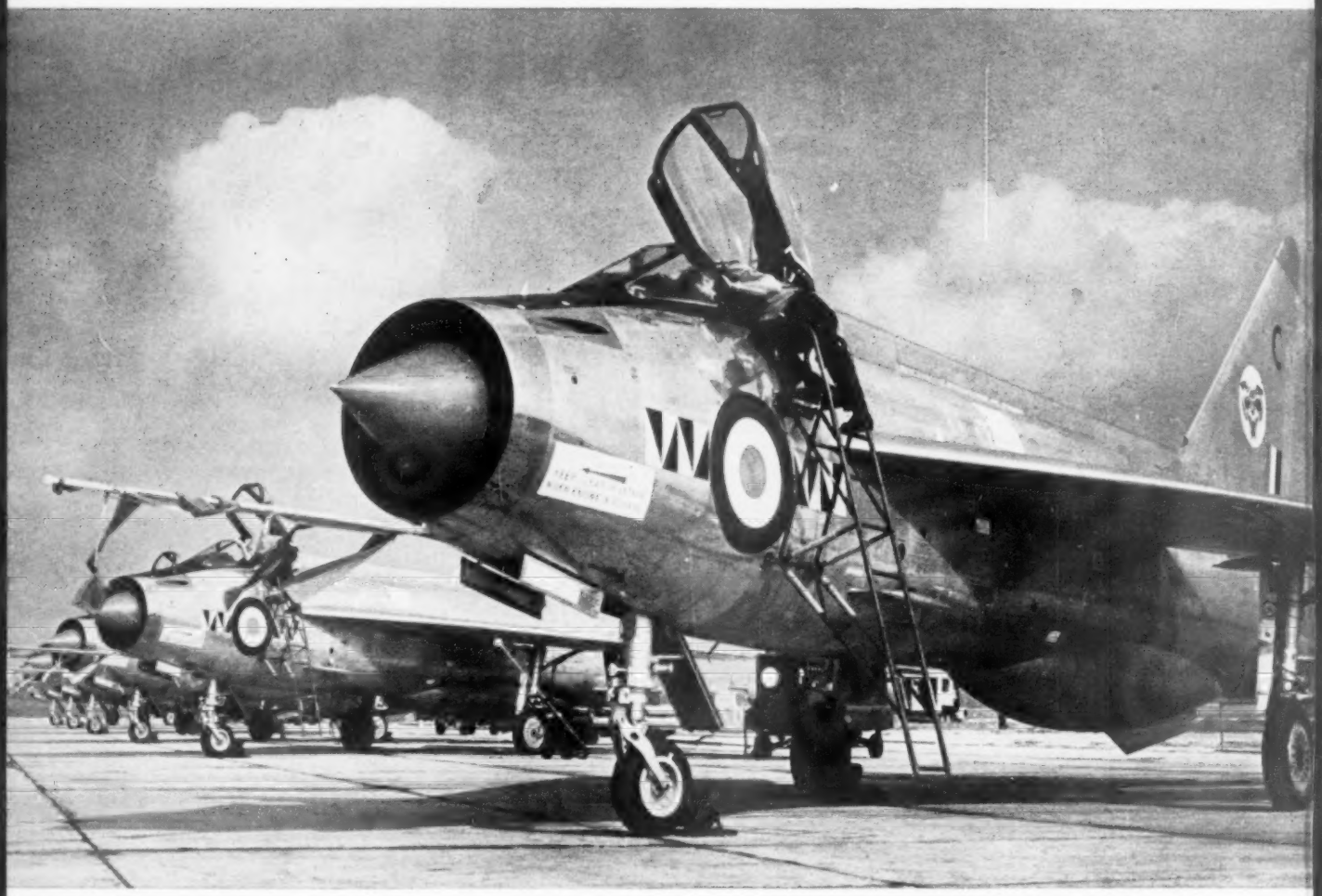
FOUR ROLLS-ROYCE TYNE TURBO-PROP ENGINES

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY A Company of

BRITISH AIRCRAFT CORPORATION

ONE HUNDRED PALL MALL LONDON SW1

THE ROYAL AIR FORCE FLIES INTO A MACH 2 WORLD



The English Electric Lightning has started its Royal Air Force career. The first squadron has been formed; others are following close behind. And so a new and most formidable defensive weapon comes into operational being—an all-weather, day and night interceptor that has twin-engine safety built into it. The Lightning is stable and docile at all speeds without the assistance of electronic devices. As a weapon system and as an achievement in applied aerodynamics, **nothing more advanced than the Lightning is in service anywhere.**

THE INCOMPARABLE *LIGHTNING*

ENGLISH ELECTRIC AVIATION LIMITED A Company of

BRITISH AIRCRAFT CORPORATION

ONE HUNDRED PALL MALL LONDON SW1

Air Transport . . . .

(*Continued from page 86*)

one or more of Boeing 707, VC.10, Super VC.10, Douglas DC-8)."

This issue of the Licensing Notices also contains details of several inclusive tour applications from Air Safaris, using Vikings and Hermes, and including some services in substitution for those already licensed by the A.T.A.C. to Orion Airways and to Maitland Drewery Aviation. A licence for the carriage of "inclusive holiday passengers" from Glasgow, Edinburgh, Newcastle, Manchester, Leeds, Wolverhampton and Birmingham to Exeter is sought by Westpoint Aviation, Ltd., of Torquay, using a DC-3.

Scottish Advisers

NAMES of the 16 members of the Scottish Advisory Committee for Civil Aviation have been announced by the Minister of Aviation, and the constitution of the similar committees for Wales and Northern Ireland will be announced in the near future. The Scottish committee is made up as follows: Mr. J. N. Toothill, C.B.E.; Lord Macdonald; Brigadier Sir Keith Murray; Dr. J. W. Macfarlane; Mrs. Edward Denny and Messrs. W. P. Broomfield, Alfred Carruthers, J. G. Dunbar, Londsay D. Gumley, Iain Hilleary, J. Gibson Kerr, J. C. Lang, Maurice McManus, G. Middleton, Donald J. Stewart and Robert Taylor.

The duty of this committee, as of those for Wales and Northern Ireland, and the Jersey, Guernsey and Isle of Man advisory councils already in existence, is to advise the Air Transport Licensing Board on the exercise of its functions. The Board's terms of reference require it, in fact, to consult the appropriate local council before holding any hearing in respect of a licence for a service to or from these local areas. The Scottish Committee, which the Minister also proposes to consult regarding aerodrome matters in Scotland, replaces the Scottish Advisory Council for Civil Aviation, which was appointed by B.E.A. Mr. J. N. Toothill is general manager of the Ferranti Edinburgh works and was a member of the former Advisory Council.

If the size of the Scottish committee can be taken as a guide, the A.T.L.B. will not be short of advice on regional operations within the U.K.. It remains to be seen in practice whether equally good briefing will be available to the Board when it considers purely English services and, most important of all, international services (see our previous issue, p. 61, "The Board and British United").

U.S. Airlines in 1960

COMPARED with the World average, the growth rate of airline traffic in the U.S. during 1960 was a modest one. According to F.A.A. estimates, the number of passengers carried on scheduled services increased by 4% to 62 million, and the revenue passenger miles increased by 6% to 38,500 million. In both cases, the percentage increases on foreign and overseas routes was considerably higher—12% and 19% respectively. The number of turbojet transports in service was approximately doubled, to 170, with another 100 on order for delivery this year. There was a corresponding reduction in the number of piston-engined airliners, but an overall 10% increase, to 78,000, in the number of active civil aircraft in use.

One result of the increased number of large-capacity jets in service was a reduction of 4% in the number of landings and take-offs controlled by F.A.A. towers for federal airways traffic. There was also a 1% drop in the revenue aircraft-miles flown, also probably as a result of the greater average aircraft capacity.

Freight and express ton-miles showed an overall 11% increase to 706 million, with an 18% increase in foreign and overseas freight. The overall passenger fatality rate increased from 0.7 to 0.8 per 100 million passenger-miles flown, with the rate for domestic operations alone, as we indicated in our 1960 accident survey on Jan. 13, reaching 1.0.

Airport Profit and Loss

THE profit and loss situation of U.K. State-owned airports provides the principal subject for the Auditor General's introductory comments in the 1959-60 Government trading accounts* and a number of valuable points are made.

The operation of these 26 airports involved a total deficit of £5.5 million by comparison with a £6.4 million loss in 1958-59. This total does not, however, include the expenses incurred in providing technical and other services for municipally owned (Manchester's Ringway) or R.A.F. joint-user (Edinburgh's Turnhouse) aerodromes; nor does it include the cost of the provision of overall civil aviation navigation aids.

This £5.5 million deficiency can be broken down as follows:—

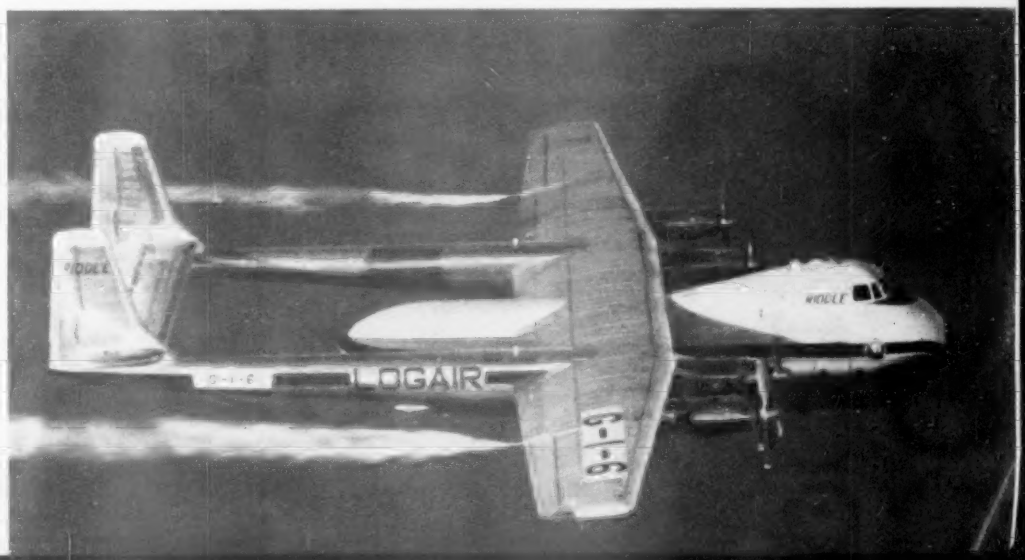
	£
London (Heathrow) Airport	1,162,226
Prestwick	434,900
Gatwick	1,068,204
Scottish "social service" aerodromes (Benbecula, Islay, Kirkwall, Machrihanish, Stornoway, Sumburgh, Tiree and Wick)	529,440
Others	2,325,336
Total	£5,520,106

The 15 aerodromes which make up the "others" include Blackpool (£119,219 loss), which is due to be disposed of, and Stansted (£204,911 loss), which is being held in reserve as an auxiliary to London's airports, and which is in limited use only.

The Auditor General's report helps to explain some of the detailed profits and losses in a series of accounts for which the expenditures and revenues are broken down in a somewhat arbitrary and complicated way. For instance, L.A.P. and Prestwick showed surpluses of £360,716 and £39,401 respectively on "aircraft handling," to which the whole of the revenue from landing fees (increased on Jly. 1, 1959) and apron services is credited. The report is mildly sarcastic about this situation, which is "as though the handling of aircraft was an activity separable from the handling of passengers and freight for whose conveyance the whole airport was operated." The Ministry admits that it is not satisfied with the present form of the accounts.

Despite earlier assurances that the Central Area would break even by about 1960-61, a separate analysis of L.A.P. results showed a deficit of £430,507. It appears that the earlier estimates did not include allowances for costs associated with the control building and the tunnel—both of which, as the report points out, "were essential to the functioning of revenue-producing services in the Central Area."

* "Trading Accounts and Balance Sheets, 1959-60: Accounts and Balance Sheets of Trading or Commercial Services conducted by Government Departments in the Year 1959-60; together with the Report of the Comptroller and Auditor General thereon." H.M.S.O. 7s. 6d.



LOGAIR SERVICE.—Riddle Airlines, which took delivery of its first Armstrong Whitworth Argosy in December, put the Dart-engined freighter into service on its Logair routes on Jan. 15. In the picture the Argosy is seen undergoing fuel jettisoning tests, with one engine feathered, before its delivery last month.

Air Transport . . . .

Air Traffic Control in the U.S.S.R.

THE November issue of *Grazhdansvaya Aviatsiya*, the journal of the Soviet Chief Directorate of Civil Aviation, which runs Aeroflot, contains an article on the experiences of an air traffic controller at one of the big control centres.

He describes the Main Regional Control Service which handles jet and turboprop traffic at heights above 4,500 metres (14,760 ft.). The control is exercised from Main Regional Control Points, or Centres (M.R.C.P.), which are situated at the principal aerodromes of Territorial Directorates and Independent Air Groups which have considerable jet and turboprop traffic. The Territorial Directorates and Independent Air Groups form the regional breakdown of the Directorate of Civil Aviation and Aeroflot over the country. Thus, for example, there are, amongst others, the Moscow T.D., the Leningrad T.D. and the Tashkent Independent Air Group.

The M.R.C.P. is equipped with its own communications and has full access to the lower height-level regional controls and airfield controls which handle piston-engined and other traffic in the lower levels. The M.R.C.P. also makes use of auxiliary radars along the route, as well as those at its base.

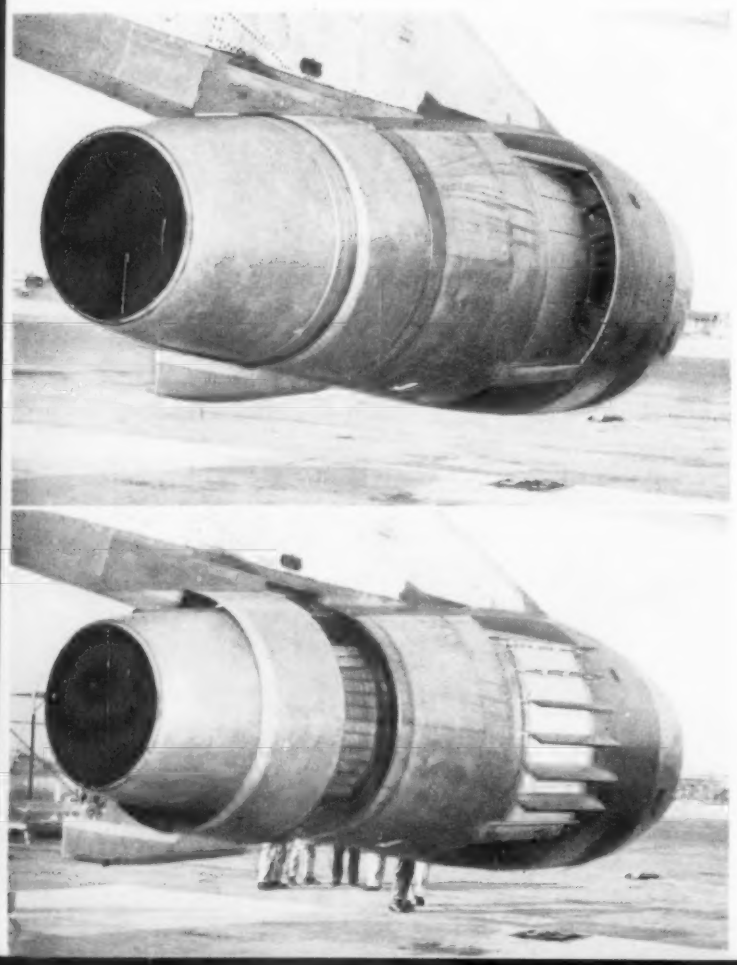
Although the M.R.C.P. control is for heights above 4,500 metres, there is an exception made in the case of descending aircraft. Here the M.R.C.P. gets instructions from the lower height control and, on the basis of these, directs the aircraft's descent down to the required height and until the airfield of destination takes over at 60 or 70 miles' range.

The M.R.C.P. also controls recall and diversion of aircraft in flight and there is a hand-over procedure as the aircraft passes from one main region to another.

The duty navigator at the M.R.C.P. of departure draws up the flight plan for the aircraft and the data are passed ahead to the next M.R.C.P. down the route. This information and that received during the flight from the radars is used by the controllers to make their decisions.

The M.R.C.P.s. it should be noted, provide definite instructions and orders to the aircraft. During flight, track-keeping instructions may be issued to the aircraft by the radars if the M.R.C.P. directs. In the event of a radar failure, VHF and short-wave D/F are used until the aircraft enters the field of another radar.

The system appears to be logical and, as stated, executive orders are issued. The hand-over procedures are thorough and should work smoothly and efficiently if communication conditions are good.—F.J.F.



FAN REVERSERS.—Details are shown here of the thrust reversers on the JT8D-1 turbofans of the Douglas DC-8 Series 50 (first flight Dec. 20, 1960). The primary stream reversers are fixed cascade assemblies, normally faired by an external sliding conical sleeve and internal clamshell deflectors. The fan stream reversers are cascades, normally covered by longitudinally hinged doors, which swing across the discharge stream when in use. Both reversers seen closed in the upper picture, are shown open in the lower picture.

Anti-collision Developments

IN the course of a year-end round-up of its work in the field of air safety, the Federal Aviation Agency has dealt at some length—as might have been expected—with its airborne collision prevention programme.

The summary concludes with the statements that a successful system "cannot be foreseen for a few years yet" and that "the most efficient means for providing safe separation between aircraft is an effective and reliable air traffic control system." It might be added, here, that the traffic situation prior to the recent New York collision suggests that self-contained prevention systems are likely to be really practicable only in non-terminal areas, where traffic is relatively sparse.

The F.A.A.'s programme covers three fields: the obvious one of "conspicuity enhancement," i.e., lights and high visibility paints; pilot-warning instruments (PWI); and collision avoidance systems (CAS). Only the third (and most technically difficult) would appear to hold promise of really successful use. However fully the pilot may be warned and informed by PWI, there will still be a possibly fatal delay while he evaluates and acts upon the threat. With CAS other aircraft will be detected, the collision threat will be evaluated automatically and the best avoidance manœuvre determined.

A promising development of CAS involves a programme designed to demonstrate the feasibility of a co-operative system based on range (distance) and altitude information only. Exchanged line-of-sight signals between aircraft will be compared with others "bounced off the ground" between them, thus providing proximity and relative altitude information which could be fed into cockpit indicators; these would inform each pilot to climb or descend as appropriate for avoidance. The capability of the ranging technique has now been tested in the air and it has been shown that successful collision-threat prediction is possible.

Ethiopian Air Lines

LAST month's attempted *coup d'etat* in Ethiopia focused attention on that country's national airline, which played a small but important part in the restoration of order. At the time of the revolt, one of Ethiopian Air Lines' three DC-6Bs was in Brazil on a charter flight carrying the Emperor, Haile Selassie. The following day it flew back with the Emperor from Sao Paulo via Recife to Robertsfield, Liberia, and then on to Ft. Lamy in Chad Republic. There, a defective exhaust valve caused some delay, the journey being continued next day, Dec. 16, to Asmara via Khartoum. On Dec. 17, the situation in Addis Ababa having been brought under control by loyal troops, the Emperor was returned to his capital in the same aircraft.

Scheduled domestic and international flights were interrupted for these three days, but four cargo flights were made by DC-3 for the military between Addis Ababa and Asmara on Dec. 17 and 18, and another DC-3 flew supplies to Dalol for an American exploration team and returned the U.S. Consul to Asmara.

During the fighting in Addis Ababa, the airline radio station was closed, and communications were maintained between two DC-6Bs on the ground—one at Addis and one at Khartoum. International services were resumed on Dec. 19.

Ethiopian Air Lines was formed in December, 1945, and is managed by T.W.A. under contract. The U.S. airline holds no stock interest, but provides staff for all senior executive posts; about 80% of the 900 employees are Ethiopian, including 21 of the 40 pilots. For the past seven years the airline has operated profitably without subsidy. The present fleet comprises three DC-6Bs for the Addis Ababa-Asmara-Cairo-Frankfurt and Addis Ababa-Khartoum-Lagos-Accra-Monrovia services and two Convair 240s and seven DC-3s/C-47s for a domestic network serving 33 points. Total unduplicated route mileage is 16,000, and two turbofan Boeing 720Bs have been ordered for introduction early next year.

Recent Past and Distant Future

THE prospects for lower fares and rates and the paramount need for Britain to keep in the forefront of aero-space engineering were among the subjects developed by Sir Percy Hunting when presenting the 1961 Lord Sempill Paper.*

In a study of air transport between 1950 and 1990, he pointed to ways in which costs might be reduced in order to lower fares and thus to attract mass-travel and bulk freight markets, and considered that World air traffic might be directed into two distinct paths—speed without regard to economy, and economy without regard to speed. If this were to be so, Britain, he said, could not neglect the development of either class of aircraft.

With the steep increase in capacity offered by the turbojets and the fact that almost every airline decided to re-equip with these aircraft, there has been a succession of efforts towards defensive co-operation between operators, with Air Union as the most ambitious of these. There was evidence of an overall decline in the rate of traffic growth, and this has been the background to a tendency towards rate increases—yet long-term interests demanded a lowering of fares. Until technical advances offered more economical aircraft, the only way to reduce direct operating costs would be by shortening turn-round times. There were better prospects of reducing indirect costs by, for instance, the pooling of engineering, spares holding and training.

A third way of reducing costs (per seat) would be by a drastic reduction of leg-room in ratio to the elapsed time of the journey. If money could be saved the passenger would accept, say, a 24-in. pitch for journey times up to three hours. The rigid limit of T34 pitch, irrespective of sector distance, was a mistake and the support from potential passengers for the very-low-fare services proposed by the British independents had proved that the traffic was there.

There was far too little research into the question of why some people fly and others do not; thousands of millions of dollars of capital have been committed by the airlines without any clear idea of the motivation of passengers.

The effects of lowered rates for freight had been calculated in a number of studies and these had shown the potential. Air freight movements were of the order of 0.01% of total freight movements, so there was ample scope. An aircraft with a payload of 200,000 lb. could match the work capacity of a rather large ocean-going fast cargo carrier.

By the development of such aids as automatic ground-air-ground communication systems (data links), automatic landing and three-dimensional radar (altitude information being the "missing link" in A.T.C. measurements), and by a refinement of existing techniques, an environment suitable for the supersonic transport could be perfected before 1970. Such an aircraft, coming ahead of military experience, would be a break with the traditional pattern of development; it would imply a risk for the airlines and a tremendous investment.

Quoted from the paper:—

Indirect operating costs . . . at something like 100% of direct operating costs, have always been accepted as one of the laws of nature . . . I am one of those who feel strongly—very strongly—that these indirect costs are susceptible to considerable reduction.

The air transport industry is poorly served in the matter of research and statistics, despite the fact that this is the basis for policy decisions.

Perhaps the major imponderable in the coming period is to what extent airlines will continue to look for State assistance to tide them over the procurement decisions of recent years.

Perhaps the future will lie in using STOL techniques not to produce short ground rolls but to lift more disposable load out of existing runways and so use the concrete that is there.

If airlines want to widen the market in the 'sixties they must expect a rough-and-tumble in which some people will get hurt.

Turbojet history must not be allowed to repeat itself with the supersonic transport—with overbuying and its consequent use on unsuitable sectors. There were signs that the closed IATA rate may eventually cease to be justified economically. If price competition broke out there would be a valid alternative to the supersonic transport in an aircraft for the low-income groups. Class levels might then be based on aircraft type instead of leg-room, and then by different standards of comfort and service in the same class. The airlines appeared to dread a galaxy of different fares, but similar things had happened in other industries and price competition seemed to improve the product as well as widen the market.

Sir Percy concluded his paper with some inspired guessing at the likely developments in the two decades following 1970—with, perhaps, the London-Paris return fare dropping to £1 10s., very big freight aircraft becoming a direct challenge to cargo shipping and the air becoming the universal common-carrier medium.

* "The World's Future Transport Requirements," by Sir Percy Hunting, lately chairman of the Hunting Group of Companies. The 1961 Lord Sempill Paper presented to the Institution of Production Engineers, Jan. 25, 1961.

Transport Helicopter Airworthiness

SEVERAL pointful and even disturbing problems in helicopter airworthiness were raised in the course of Mr. H. E. le Sueur's lecture*, on Jan. 13, to the R.Ae.S. Rotorcraft Section. His discussion was based on the premise that, whatever the helicopter's VTOL and other special capabilities, it would not be permissible to relax standards of safety; it was better that these standards should be set as high as possible and any accruing bonus enjoyed.

So far, helicopters had been shown to have low mechanical and powerplant reliability, but the high recorded accident rates were due mainly to the fact that the majority of existing aircraft were single-engined and used for general purposes. Crew-error accidents which, as the table shows, preponderated in such "general" operations, would be greatly reduced in public transport work.

After summarizing the effects of an acceptable engine-failure rate on operating rules and before explaining some of the safe take-off techniques and patterns, Mr. le Sueur discussed the reserves of engine power required in different régimes of flight.

Major Accident Rates per 10,000 hours Divided into Cause Groups

Type of operation	Total	Crew	Mechanical	Engine	Other
Helicopter:					
General	7.6	3.6	1.3	0.8	1.9
Scheduled	1.2	0.1	0.3	0.7	0.1
Modern Aeroplane ..	0.3	0.1	0.1	0.02	0.1

Although the ratio of extra power required after engine-failure on take-off by a twin-engined helicopter was higher than in the case of a fixed-wing aircraft, this more-than-take-off power would normally be used only in the event of engine failure. With turbine powerplants a 10% increase in take-off power, used for no more than 2½ minutes and not more often than 10 times between overhauls, should have little or no more adverse effect than the use of normal maximum power for every take-off, as with an aeroplane. Helicopters needed to use no more than maximum continuous power for routine take-offs.

The accident rate due to mechanical faults had been high with helicopters. Unfortunately the rotor and transmission systems—which corresponded to the primary structure of an aeroplane—did not lend themselves to duplication as a means of guarding against the catastrophic results of any failure. Integrity had to be guaranteed by other means.

Discussing safe fatigue life, Mr. le Sueur showed the extreme significance of a factor to allow for scatter in material properties and assembly stresses. As an example he discussed a light-alloy part of a rotor with an apparent safe life of 10,000 hr. Its reliable safe life could be shown to be only 40 hr. and the conclusion was that the part should be designed for infinite life with a factor of 3.

For the transmission system, in which failure of any part could be catastrophic, there would need to be a very thorough test programme covering endurance, vibration analysis (including resonance), fatigue life and operational abuses.

* "The Certification of Civil Transport Rotorcraft with Particular Reference to Multi-Engines," by H. E. le Sueur, A.F.R.Ae.S., of the Air Registration Board.

Aero-turbine Materials

An analysis of current trends by T. A. TAYLOR*, M.Sc., Ph.D., F.I.M. *Airframe materials were discussed by* Prof. A. J. KENNEDY *in our previous issue.*

IN the very earliest stages of the development of the gas turbine aero-engine before the Second World War, the only special materials available for the construction of the all-important turbine components were those used in steam turbine practice; it was with these materials that the Whittle W1-type engine achieved a thrust of 800 lb. in 1940. In the 20 years which have elapsed, the thrust of the largest engines has been increased almost 30-fold, and the specific fuel consumption nearly halved. These achievements have been accompanied by an increase in turbine inlet temperature of some 150° C., which has been made possible by the concurrent improvements in high temperature materials.

Today, further progress is greatly dependent upon our ability to make still further improvements in high temperature materials. The benefits to be derived from higher operating temperatures are well illustrated by the curves in Fig. 1 in which specific output is plotted against cycle temperature at both subsonic (M=0.7) and supersonic (M=2.5) flight speeds at 36,090 ft. and a compressor temperature rise of 300° C.

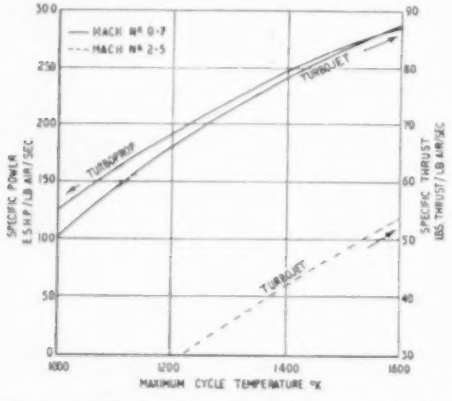


Fig. 1.

The availability of greater specific thrust leads to a roughly proportionate reduction in specific weight.

One of the obstacles to the utilization of these potential advantages is the likelihood of the noise level increasing to an unacceptable extent. For this reason greater attention is being devoted to the ducted fan engine with increased by-pass ratio, accompanied by a high cycle temperature and pressure ratio, and an acceptable noise level. The advantages which may thus be gained are illustrated in Table I, for a hypothetical supersonic engine. The problems, and the opportunities, facing engine designers are in many respects similar to those encountered in the past, but it seems probable that it will be much more difficult to maintain the same rate of progress, as a closer study of the development of materials will reveal.

An increase in operating temperature makes additional demands not only upon the turbine but on the combustion system and the exhaust gas ducting. Similarly, an increase in the temperature rise through the compressor plus the effects of flying at supersonic speed raises the operating temperature in the final stages of the axial compressor. In fact, all major components of the engine can derive benefit from improvements in material properties, particularly in respect of strength/density ratio. In the present article, the current state of development of materials for only a few of these components can be discussed.

Turbine Blade Materials

The aircraft gas turbine began its life with turbine blades made from creep resisting iron-base alloys, but these were rapidly superseded by nickel-base alloys, which have established a virtual monopoly for this application, with only modest competition from alloys based on cobalt. Based originally on the 80% nickel-20% chromium composition, these alloys have been extensively described in the published literature (Ref. 1 and 2).

Intensive development both in the United States and in the United Kingdom has resulted in the gradual evolution of a series of alloys of complex composition, deriving their high temperature strength partly by the precipitation of the intermetallic phase $Ni_3(Al, Ti)$, partly by stiffening the nickel-chromium solid solution with elements like cobalt, molybdenum, and tungsten, and additionally by minute amounts of boron and zirconium. Their progress is indicated in Fig. 2, in which the properties are expressed as the temperature for fracture in 100 hours at a stress of 8 tons/sq. in.

Development of alloys is a stepwise rather than a continuous process, but the mean rate of advancement which may be deduced from Fig. 2 is about 8-9° C. per year. During the past four years or so, progress has been more rapid than this, largely, it is thought, due to the impetus given by the use of vacuum melting. More will be said about vacuum melting at a later stage, but in brief its merits are that it permits closer control of alloy composition, greater freedom from harmful impurities, and improved hot working characteristics.

All the recent alloys in this class are vacuum processed in one way or another, the most recently introduced wrought alloys in this country being Nimonic 115 and G.70. The stress/rupture properties of some of the best alloys available at present are plotted against temperature in Fig. 3. The load carrying ability of these alloys at high temperatures represents a truly remarkable achievement when it is remembered that they begin to melt at a temperature close to 1,300° C.: this means that the permissible operating temperature is more than 80% of the melting point, a feat which has not been equalled by any other alloy system.

TABLE I

Effect of improving high temperature materials in by-pass engine for M=2.2

Max. cycle temperature	1400°K	1600°K
By-pass ratio	0.85	1.6
Specific fuel consumption	100 per cent.	96.5 per cent.
Weight	100 per cent.	80.0 per cent.

N.B. Both engines uncooled, with same thrust and jet noise level.

It will be noticed that in Fig. 2 two curves have been drawn, one representing wrought alloys and the other cast alloys, and that the latter have consistently maintained the higher stress/rupture properties. Both types have benefited by vacuum melting, but a slight divergence has been given to the curves to express the probability that at the very highest operating temperatures the cast structure has better load bearing properties than a homogenized, hot worked structure.

In the United States, attempts have consistently been made to use cast alloys for turbine rotor blading, the greatest success coming with the advent of vacuum melting and the alloy

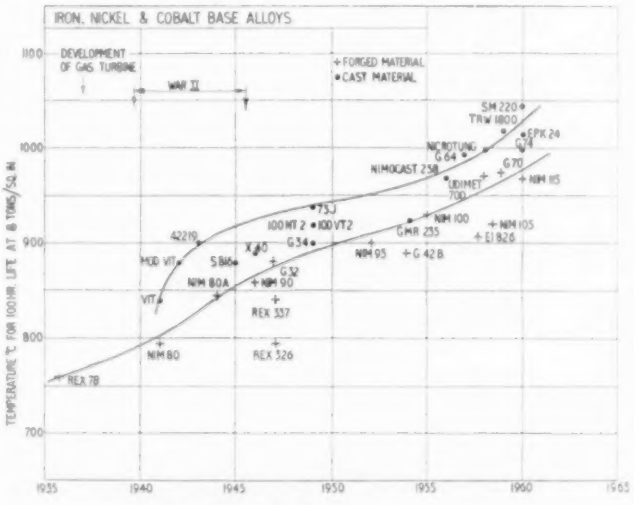


Fig. 2.

* National Gas Turbine Establishment, Ministry of Aviation, Pyestock, Farnborough.

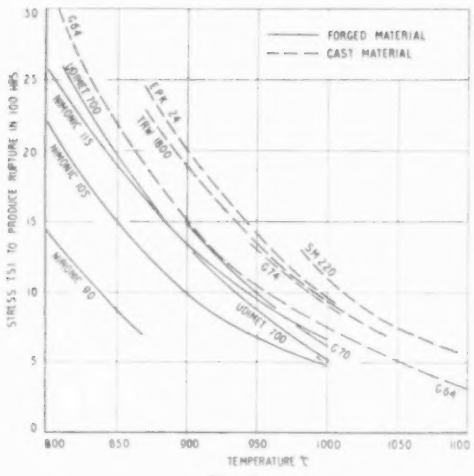


Fig. 3.

GMR235 (Ref. 3). Much less interest has been shown in the United Kingdom, largely on account of fears of excessive scatter in properties and inadequate ductility.

Recent experience at Bristol Siddeley Engines, Ltd., however, has shown that these problems can be overcome and very satisfactory results have been obtained with the alloys X.40 and G.64 in the Proteus. The G.64 blades are cast into refractory moulds in vacuum or in an atmosphere of argon using melting stock which has previously been prepared by vacuum induction melting. Test bars cast in the same mould as the blades have no difficulty in meeting a specification of 50 hours minimum life at 900° C. under a stress of 15 tons/sq. in. The casting conditions are designed to give freedom from micro shrinkage and a fine carbide cell size.

The macro grain size of G.64 tends to be somewhat coarse and although this does not seem to have an important effect on service behaviour it has recently been found possible to refine and control it independently of pouring temperature and mould temperature. The relatively low ductility of G.64 does not appear to have any detrimental influence on the performance of the blades except to render them slightly more prone to impact damage compared with blades made from wrought materials.

It has been found that some turbine blade alloys are prone to suffer from corrosion at high temperatures in the presence of sulphur containing compounds, especially sulphates. G.64 does not exhibit particularly good corrosion resistance under these conditions and a protective coating is therefore applied before the blades are put into service. This consists of an aluminizing treatment which provides a high degree of resistance to sulphate attack, and additionally improves both oxidation and thermal fatigue resistance.

Bench tests have resulted in severe corrosion of uncoated blades while coated blades from the same engine have been entirely corrosion free. Fig. 4 shows typical corroded and uncorroded blades.

Approximately 100,000 hr. total running experience has now been accumulated by G.64 blades at the Proteus 750/760 series rating without the occurrence of any creep failures or creep cracks; the longest running period for a particular set of blades in service is at present 2,500 hr. Bench testing is being carried out at higher than normal turbine inlet temperatures, one engine having achieved 1,000 hr. running 40° C. hotter, and another 100 hr. at a temperature 100° C. higher than normal.

This successful operating experience reflects great credit upon both material supplier and foundry. It should stimulate interest in using casting alloys of still greater strength than G.64: the knowledge gained in the techniques of metallurgical control during manufacture should prove invaluable in this respect.

Compressor and Turbine Discs

These components are considered together, as they present a similar design problem, and operate over a temperature range up to about 500° C. In the earliest engines the turbine discs were of austenitic steel, and although these were satisfactory, the need for reduced weight led to the adoption of low alloy martensitic steels with much higher levels of mechanical properties, creep at the disc rim being controlled by air cooling techniques. These alloys in turn have given way to the 12% chromium martensitic steels of the S.62 type, initially on account of their superior resistance to corrosion.

This class of steel has undergone intensive development during the past decade. Systematic studies have been made of the effects of alloying elements on the basic composition, of which Ref. 4 is a good example. We now have a far clearer

Fig. 4. Cast G.64 rotor blades from Proteus engines. Right, aluminized blade, uncorroded. Left, uncoated blade showing extensive high temperature corrosion.

understanding of the physical metallurgy of these steels, culminating in the production of a series of complex alloys such as H.46, F.V.448, Jethete M160, H.53, F.V.535, and Jethete M210. The compositions of these steels are given in Table II and the mechanical properties and creep resistance of the class are indicated in Fig. 5.

Efforts to extend the usefulness of the 12% chromium steels to still higher temperatures are being continued. Prevailing opinion seems to be, however, that little further progress is possible.

The trend towards higher turbine inlet temperatures will inevitably tend to force up the temperature of the rim of the turbine disc. In the case of engines for supersonic flight this will be particularly marked, in view of the fact that the air bled off from the compressor for cooling purposes will be substantially hotter than the air available for disc cooling in current engines: the outlet temperature from such compressors may easily reach 500° C., and turbine disc rim temperatures may well exceed 700° C. Temperatures of this order will almost certainly be beyond the scope of the martensitic steels and will thus lead to a return to the use of austenitic steels or nickel-base alloys.

In the United States, alloys in this class such as A.286 and Discaloy have been used extensively for many years and recently disc forgings have been produced in much stronger materials such as René 41 and Waspaloy. Experience in the production and operation of turbine discs in such materials is very much more limited in the United Kingdom, but development is active. Fortunately, it appears that manufacturing

TABLE II

Chemical composition of some turbine and compressor disc materials

	C	Mn	Si	Ni	Cr	Mo	Ti	W	Nb	Co	V	Fe	Al	Sn	Zr	B	Cu	Mg
S.62	0.25	0.25	0.25	0.4	13.5							rem.						
H.46	0.16	0.7	0.3		11.6	0.6			0.25		0.3	rem.						
H.53	0.08	0.8	0.3	0.25	10.5	0.8		0.8	0.45	7.0	0.55	rem.						
F.V.448	0.10	0.8	0.5	0.75	10.5	0.65			0.4		0.2	rem.						
F.V.535	0.08	1.0	0.4	0.3	10.5	0.75			0.45	6.0	0.2	rem.						
Jethete M160	0.14	0.95	0.3	1.0	12.0	0.6			0.25		0.3	rem.						
A.286	0.08 max.	1.6	0.65	25.0	15.0	1.25	2.1				0.3	rem.	0.2			0.003		
René 41	0.09			rem.	19.0	10.0	3.0			11.0			1.5			0.005		
Nimonic 90	0.13 max.	1.0 max.	1.5 max.	rem.	19.5		2.4			18.0			1.4					
Hylite 50	0.04		0.5			4.0	rem.					0.1	4.0	2.0				
I.C.I. 679			0.2			1.0	rem.						2.25	11.0	5.0			
R.R. 58			0.25 max.	1.1			0.2 max.					1.2	rem.				2.3	1.5

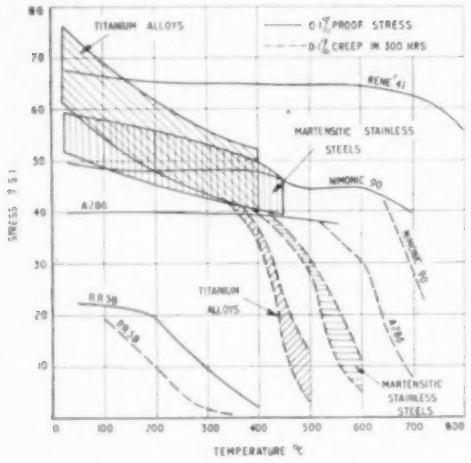


Fig. 5.

problems will not be too serious; Nimonic 90 is being employed as an interim measure and has already been forged into discs up to 29 in. diameter.

The alloys G.80 and G.81 (similar to Nimonic 80A and Nimonic 90) can also be hot worked into discs up to 30 in. diameter and up to 300 lb. weight, and 4 ft. diameter discs have been produced in G.68 (equivalent to the American A.286). The mechanical properties of some of these materials are included in Fig. 5; the mechanical and stress rupture properties of typical discs have been described elsewhere (Ref. 5).

At the other end of the temperature scale, aluminium alloys are still preferred for compressor discs on account of their useful strength/weight ratio up to about 180° C., ease of fabrication, and modest cost. Up to 450° C., however, it is the titanium alloys which exhibit the most attractive range of properties, as revealed by Fig. 6, in which mechanical properties, factored for density, are plotted against temperature.

The fatigue properties of titanium alloys are of a high order while in the notched condition the fatigue strength of these alloys reaches 50-60% of the unnotched value. Their corrosion resistance is, of course, outstanding. The two foremost British titanium alloys, Hylite 50 and I.C.I. 679, have both been produced in the form of large diameter discs and the forgeability is roughly similar to that of the 12% chromium steels.

The major obstacle to wider usage of these alloys is an economic one, the current price of billet material for forging being £2 to £3 per lb. This is considerably cheaper than when titanium alloys first became commercially available, but is higher than the price in the United States, which is now $4 to $5 per lb. The cost of a typical titanium alloy disc forging is about six times that of a similar one in 12% chromium steel.

New titanium alloys with improved properties at both low and high temperatures continue to appear, but so far titanium has been disappointing as a basis metal for really high temperature service, having good engineering properties only up to about 40% of its melting temperature.

Failure of a turbine or compressor disc in service is the most catastrophic form of engine failure which can occur, and it is for this reason that maximum importance is attached to disc reliability. A large proportion of the discs currently being manufactured are forged from vacuum melted ingot, to ensure the highest possible standards of quality. The consequent reduction in the number of discs rejected for defects goes a long way to offset the increased cost of production.

Although we may now claim to have a better understanding of the relationship between the metallurgical characteristics of disc materials and their mechanical properties as measured by conventional tests, our knowledge of the behaviour of the material in the form of a rotating disc is less satisfactory. The compressor or turbine disc is one of the few cases in engineering where designers deliberately design for stresses high enough to cause plastic flow. The assumption is made that the peak stress in the bore of the disc will be redistributed and the disc will behave as if uniformly stressed, but if this does not occur the strength of the disc material is not being fully utilized.

This problem is under investigation at the National Gas Turbine Establishment, the objective of the research being to develop more precise methods for disc design. Bored discs in various materials and of varying diameter and thickness are being spun until they burst, and the bursting stress correlated with the mechanical properties.

Some of the preliminary findings are illustrated in Fig. 7. The curve AB of the diagram indicates that if discs of a given material are heat treated to successively higher tensile strengths they will burst at a speed corresponding to a stress equal to the ultimate tensile strength of the material. At the point B, however, a change in behaviour occurs and if the material is heat treated to a higher strength C the disc bursts at a stress D, which is lower than both C and B.

A material of higher ductility may depart from linear behaviour in a similar way, but at the higher stress level C. This suggests the existence of a critical combination of strength and ductility, for a given material and disc geometry, beyond which the non-uniform stress in the disc cannot be redistributed. If the bore of the disc is notched, however, the benefits of the higher ductility appear to be greatly reduced. By means of these experiments it is hoped to devise a more representative criterion of ductility than the conventional elongation in a tensile test and use it in plastic/elastic stress calculations.

Some current problems

One of the potential causes of turbine blade failure is the transient thermal stress developed in the blade during starting or stopping of the engine. Repetition of these stresses leads to failure by thermal fatigue cracking. This is a problem which may well increase in magnitude with increase in turbine inlet temperature.

Laboratory research by the author and his colleagues has been directed towards the identification of the significant factors which control the failure of turbine blade alloys by thermal fatigue. A novel experimental technique was devised, employing hot and cold beds of fluidized solids as the heating and cooling media (Ref. 6). Many alloys were tested, but the bulk of the experiments were made on Nimonic 90. The preliminary results, which have recently been published (Ref. 7), have led to the following conclusions:—

(i) A succession of heating shocks is, generally speaking, much more damaging than a succession of cooling shocks occurring between the same temperature limits (T_1 and T_2). This is believed to be due to the fact that rapid heating produces a transient compressive strain at the surface of the material, of sufficient intensity to cause plastic deformation. In consequence, when the specimen reaches an equilibrium temperature a residual tensile strain remains in the surface layers acting at the maximum temperature, when the material is at its weakest. In a cooling shock, the maximum transient tensile strain is developed in the surface at a much lower temperature, where the material is relatively strong.

(ii) The residual tensile strain is developed to its fullest extent only if sufficient time elapses for the specimen to reach thermal equilibrium. If the heating time is insufficient

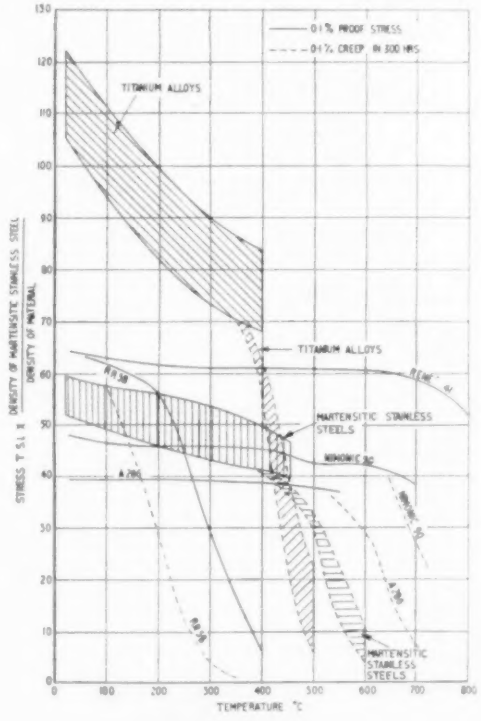


Fig. 6.

the severity of the heating shock is reduced, and the thermal endurance may be greatly increased.

(iii) The upper temperature of the thermal cycle has a powerful effect on the onset of cracking.

(iv) The mode of cracking is intergranular for most alloys, above a characteristic threshold temperature.

(v) Surface oxidation, if intergranular in nature, contributes to earlier failure by thermal fatigue.

One of the lessons to be learnt from these results is that better control over starting conditions could lead to a reduction of the severity of the heating shock, and hence increase blade life. Fig. 8 is a diagram representing the thermal conditions experienced by a turbine blade under a normal (rapid) starting sequence, and for a more gradual start by means of which the initial transient temperature peak is eliminated.

Tests under similar conditions have been made at the NASA (Ref. 8 and 9), Lewis Research Center, on a J47 engine bladed with a variety of alloys. The engine was subjected to repeated cycles of starting and stopping, interspersed with periods of steady state operation: both rapid and gradual starts were

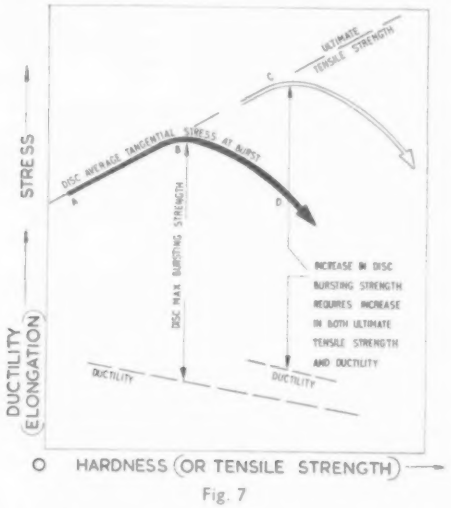


Fig. 7

employed. The results showed conclusively that gradual starts failed to initiate cracking, but normal starts caused cracking after running periods immeasurably shorter than would be expected from the rupture strength of the materials. Such cracks are liable to propagate by vibration fatigue, leading to complete fracture.

An interesting materials problem has occurred during the development of the Westland (Fairey) Rotodyne. Considerable research effort has been devoted to the suppression of noise from the pressure jet units driving the main rotor. A silencer has been designed for these units, giving a noise suppression of 7 dB. This is a sheet metal construction through which is passed the exhaust gas at a temperature of about 1,750° C. and a velocity of 3,000 to 4,000 ft./sec.

The silencer consists of a number of lobes dividing the gas passage into a star-shaped configuration. The extreme tips of these lobes are exceedingly difficult to cool, and may reach a maximum temperature of 1,500° to 1,600° C. Conventional heat-resisting alloys have a short life because their melting point is exceeded locally and the tips of the lobes are burned away. Rig tests on a wide variety of alternative materials have shown that molybdenum (m.p. 2,622° C.) suitably protected against oxidation gives a very much longer life.

The protective coating used is well known, and consists of a mixture of chromium, silicon, and aluminium sprayed on in the form of powder and subsequently sintered *in vacuo* at 1,100° C. to yield a coating about 0.010 in. thick. Other materials are also being investigated for this application.

New Processes

New and improved processes for the production of gas turbine materials and components are beyond the scope of the present article, but the picture would be incomplete without a brief discussion of vacuum melting (Ref. 5 and 10). This process has had a profound effect on the production and properties of turbine blade and disc materials, and its use is rapidly being extended for other purposes such as bearings and sheet materials for high temperature service. It is undoubtedly responsible for the increased rate of progress since 1955, indicated in Fig. 2.

There are two main methods in commercial use, (a) vacuum induction melting, (b) consumable electrode vacuum arc melting.

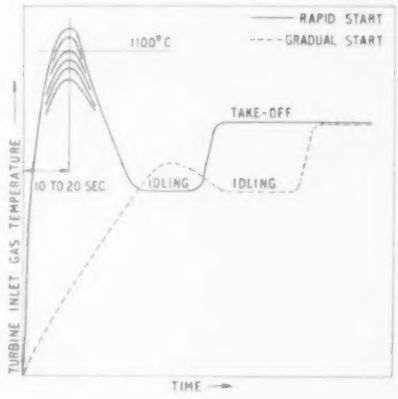


Fig. 8

Vacuum induction melting is particularly advantageous for the nickel-base, creep-resisting alloys because it prevents uncontrolled losses of easily oxidized elements like titanium and aluminium, removes gaseous impurities, and facilitates a much stricter control of the final composition; this in turn leads to the development of far more consistent properties than are attainable by air melting.

Consumable electrode vacuum arc melting has its own peculiar virtues. Unwanted impurities are volatilized, non-metallic inclusions broken down and dispersed and the mode of freezing is such that segregation and unsoundness at the centre of the ingot are greatly reduced.

For this reason, vacuum-arc-melted ingots exhibit vastly improved hot working properties, and it is this factor that has made possible the production of large disc forgings and sheet in alloys of high creep strength. Such forgings are much more isotropic in properties, especially in the 12% chromium steels. The improved ductility and forgeability make it possible to increase the total alloy content, and hence to increase high temperature strength without loss of ductility.

When the highest possible quality is needed, as in disc forgings, the current practice is to employ double vacuum melting, i.e. to produce vacuum-induction-melted ingots which are used as electrodes for remelting in the vacuum arc furnace.

Production capacity for vacuum processing is increasing rapidly in the United Kingdom. At the works of Jessop Saville, Ltd., there are vacuum induction furnaces of 600 lb. capacity, and a larger one of 2,200 lb. capacity is being installed: ingots up to three tons in weight can be made in consumable electrode arc furnaces. Equipment now available to Henry Wiggin and Co., Ltd., or shortly to be installed, will enable ingots weighing up to 4,000 lb. to be produced by consumable electrode vacuum arc melting, from electrodes made either by vacuum induction melting or vacuum refining of air melted material.

Thos. Firth and John Brown, Ltd., are also installing consumable electrode vacuum arc melting equipment capable of producing ingots up to 26 in. diameter and up to seven tons in weight. In the United States, vacuum melting facilities are on an even larger scale. The Kelsey Hayes Co. has a vacuum induction furnace of 5,000 lb. capacity and Universal Cyclops have consumable electrode vacuum arc furnaces up to 25,000 lb. capacity.

(To be concluded.)

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The Fighting Services

Senior Command Appointments

AIR VICE-MARSHAL SIR LESLIE DALTON-MORRIS, K.B.E., C.B., is to become Air Officer Commanding-in-Chief, Maintenance Command, with the acting rank of Air Marshal on Mar. 1. He will succeed Air Marshal Sir Douglas Jackman, K.B.E., C.B., who will be retiring from the Service.

At present A.O.C.-in-C., Signals Command, Air Vice-Marshal Dalton-Morris was previously Assistant Chief of the Air Staff (Signals). Before that he was Chief Signals Officer, Middle East Air Force.

Air Vice-Marshal W. P. G. Pretty, C.B., C.B.E., is to take over the appointment of A.O.C.-in-C., Signals Command, on Jne. 1. Director-General of Organization at the Air Ministry since October, 1958, he was previously with 2nd T.A.F. as Air Officer in charge of Administration. Air Vice-Marshal Pretty has also held the post of Director of Electronics Research and Development (Air) at the then Ministry of Supply.

Air Cdre. P. E. Warcup, C.B.E., has been appointed Assistant Commandant of the R.A.F. Staff College, Bracknell, in succession to Air Cdre. F. O. S. Dobell, C.B.E., who has become Senior Air Staff Officer at No. 1 Group, Bomber Command. Air Cdre. Warcup took the 1960 course at the Imperial Defence College, having previously commanded R.A.F. Kuala Lumpur, Malaya.

At Bracknell since January, 1960, Air Cdre. Dobell was on the staff of Marshal of the R.A.F. Sir William Dickson, the first Chief of the Defence Staff, in 1957-59. Before that he commanded R.A.F. Binbrook.

Air Cdre. W. Macl. King, C.B.E., until recently Commandant of No. 16 Maintenance Unit, R.A.F. Stafford, is to become a Director of Equipment at the Air Ministry. From 1955-56 he commanded No. 107 M.U. at Kasfareet in the Canal Zone, and in 1957 became Senior Equipment Staff Officer at H.Q. Middle East Air Force. Before going to Stafford he was on the directing staff of the R.A.F. Staff College, Bracknell.

Direct Entry Commission Changes

TWO new types of commission for R.A.F. aircrew have been introduced which, while preserving opportunities for a pensionable career, allow officers the option of leaving the Service with a gratuity at certain intermediate stages.

In future, officers taking up Direct Entry commissions which provide for a pensionable career to the age of 38 or extending over 16 years, whichever is the longer, will have the option of terminating their service at the end of eight or 12 years. If they do not take up their options but complete the full term of service, they will be eligible for the normal rates of retired pay and terminal grants. Those exercising their options will receive gratuities of £4,000 after 12 years' service, or £1,500 after eight.

The other change is the introduction of restricted opportunities for Direct Entry commissions with option points at five and eight years; for five years' service the gratuity will be £775.

Army Air Corps Alouettes

AN order has been placed with Sud-Aviation for 12 S.E.3130 Alouette 2s for the Army Air Corps. This follows an earlier purchase a month ago of five Alouettes, and brings the total Army contract up to 17. Deliveries are expected to start in the very near future.

The Alouette 2, the prototype of which first flew in March, 1955, is powered by a Turboméca Artouste 2 shaft turbine. A general-purpose helicopter, it has five seats, a normal all-up weight of 3,300 lb., and an economical cruising range of 330 miles.

NEW A.O.C.-in-Cs.—As recorded on this page, Air Vice-Marshal W. P. G. Pretty (left) is to become A.O.C.-in-C., Signals Command, in June, and Air Vice-Marshal Sir Leslie Dalton-Morris has been appointed A.O.C.-in-C., Maintenance Command, with the acting rank of Air Marshal.

R.A.F. Appointments

THE following are among recent Royal Air Force appointments:—

Air Ministry: Wg. Cdr. F. C. Barter, A.F.C., to the Department of the Chief of the Air Staff; Wg. Cdr. R. E. Powell and Wg. Cdr. H. H. Sims to the Department of the Air Member for Supply and Organization.

Bomber Command: Wg. Cdr. H. L. Derwent, A.F.C., to R.A.F. Hemswell as Wg. Cdr. Operations; Wg. Cdr. P. C. Lambert to Headquarters for organization duties.

Coastal Command: Wg. Cdr. D. E. Hawkins, D.F.C., to Headquarters, No. 19 Group as Senior Air Staff Officer, with acting rank of Gp. Capt.

Flying Training Command: Wg. Cdr. H. Drake to No. 5 Flying Training School, Oakington, as Senior Technical Officer; Wg. Cdr. R. B. Fleming, D.F.C., A.F.C., to Headquarters for work study duties.

Technical Training Command: Wg. Cdr. D. J. Garland to Headquarters for educational duties; Sqn. Ldr. P. Kirk, D.F.M., to the Officer Cadet Training Unit, Jurby, Isle of Man, to command the Administrative Wing, with acting rank of Wg. Cdr.

Maintenance Command: Gp. Capt. P. H. Stibbs to Headquarters as Senior Personnel Staff Officer.

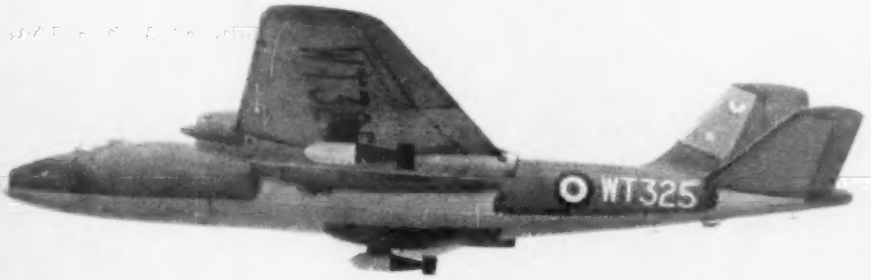
Other Appointments: Wg. Cdr. W. K. Bell, O.B.E., to the Ministry of Aviation for liaison duties; Wg. Cdr. P. P. Villa to Allied Air Forces Southern Europe for operations duties.

More Service News

R.A.F. Benevolent Fund.—Air Cdre. W. H. Hutton, C.B.E., has been appointed secretary (Relief) of the R.A.F. Benevolent Fund in succession to Gp. Capt. C. E. J. Baines, C.B.E., who had held the post since 1958. For the past three years Air Cdre. Hutton has been in charge of the Fund's education branch.

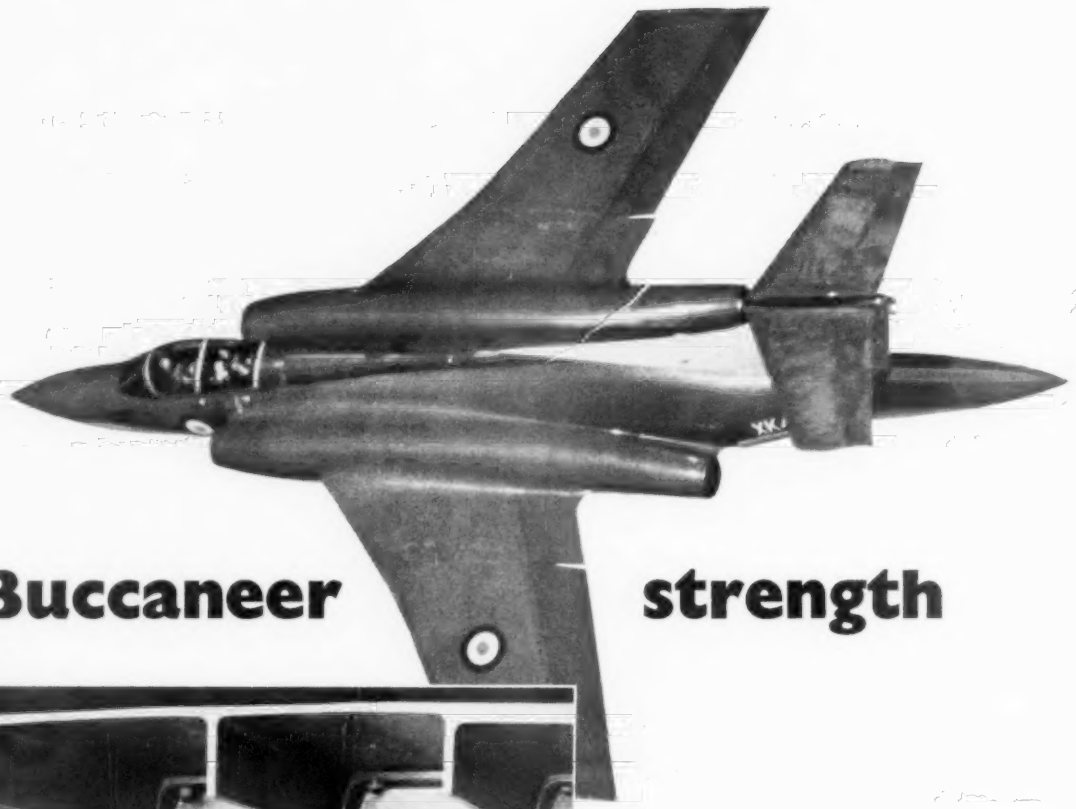
Record Profits.—Proceeds from last year's Battle of Britain Day were the highest on record in spite of fewer stations being open to the public. The sum of £35,000 was received from 25 R.A.F. stations, of which half has gone to the R.A.F. Benevolent Fund and half to the R.A.F. Association.

Newcastle Visitor.—Marshal of the R.A.F. Sir Dermot Boyle is to visit Newcastle on Feb. 2, where he will deliver a lecture on the rôle of the R.A.F., in the Physics Auditorium of King's College. Before the lecture Sir Dermot will have tea with members of the Durham University Air Squadron and in the evening he will be the guest of honour at a private dinner party to be given by the Vice-Chancellor.

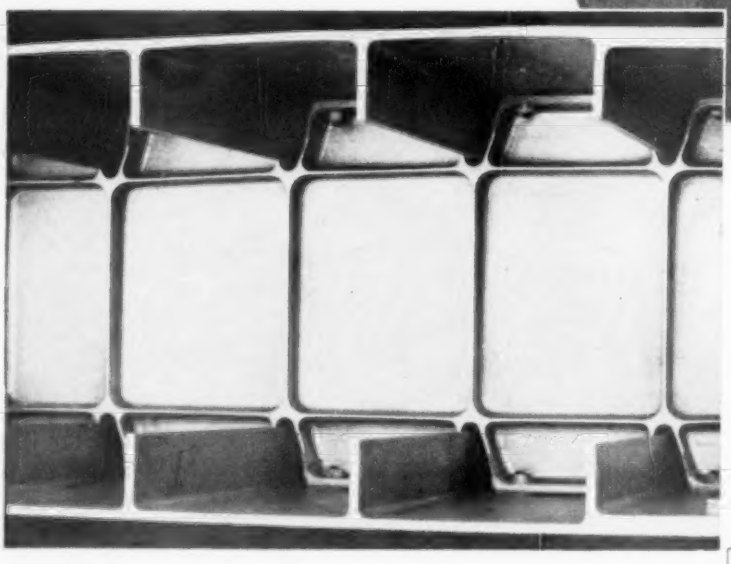


TACTICAL OPERATOR.—A Canberra B(I).6 of No. 213 Squadron. Commanded by Wg. Cdr. P. J. Bayley, the Squadron is based at R.A.F. Bruggen and operates with the 2nd T.A.F. in Germany.

Windscreens by TRIPLEX

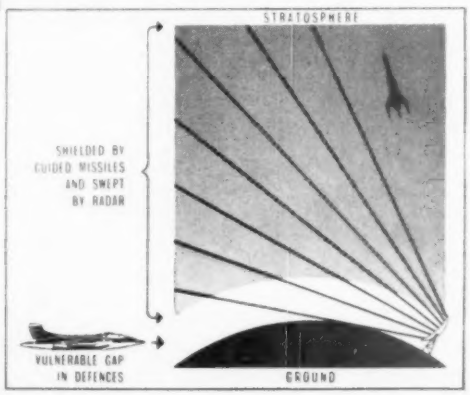


Buccaneer strength



An example of Blackburn integral construction

High-speed, low-level operations demand that the Buccaneer aircraft have great structural strength and stiffness combined with a long operating life. Integral construction of the Buccaneer ensures stiffness but, in addition, Blackburn engineering has built in the long-life factor.



Blackburn

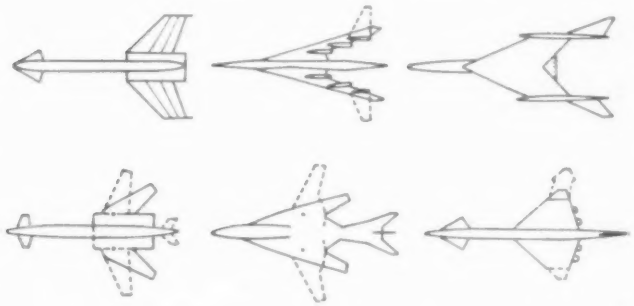
BLACKBURN AIRCRAFT LIMITED, BROUGH, YORKSHIRE, ENGLAND
Member Company of the Hawker Siddeley Group

U.S. Programme for a Mach 3 Airliner

IN America, the Federal Aviation Agency has published a report* which advises the Government to back the development of a supersonic airliner. Its administrator, E. R. Quesada, recommends "that the executive and legislation branches of our Government give prompt and careful consideration to the immediate establishment of a national programme for the development of a commercial supersonic transport aircraft."

According to *Aviation Week*, the Defense Department and Budget Bureau have earmarked $5 million of 1961 fiscal-year funds for the programme outlined. This was a cut from the $17.5 million requested by Quesada and the retiring NASA administrator, Keith Glennan. The future of the proposed programme will depend on the views of the Kennedy administration.

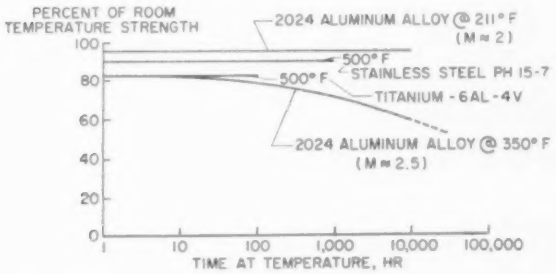
As a result of the B-58 and B-70 programmes and earlier supersonic research, the report concludes, the U.S. has "a unique capability of developing a safe and economically competitive supersonic transport. The magnitude of the development task and the current financial situation of the United States aviation industry preclude its accomplishment on a timely basis solely by private enterprise." Elsewhere in the report the cost of development is put at above $500 million.



CONFIGURATIONS.—The F.A.A. report included those supersonic configurations which have been studied in the U.S. Several use variable geometry to improve take-off, landing and low-speed performance.

The report considers that it is now technically feasible to develop a commercially competitive supersonic transport of intercontinental range. "Flight efficiency and direct operating costs comparable to those of current subsonic jet transports are indicated." Not all the technical problems have been solved. But a solution is possible by a vigorous national effort combining the efforts of industry and the appropriate Government agencies.

A range of arguments is quoted in favour of a U.S. supersonic-airliner programme. These include maintaining the U.S. position as the major supplier of transport aircraft; the economic effect (at present aeronautical exports by the U.S. are worth over $500 million annually and make up 12% of exports of all manufactured goods); maintenance of national prestige and the advantage to national security of having supersonic airliners as potential troop transports; and the likelihood of Britain and Russia producing supersonic airliners.



MATERIALS.—The reduction in the strength of structural alloys after prolonged heating is a problem mentioned in the F.A.A. report. Data are not available at present for heat-soak times above 10,000 hr., whereas the life required for airframes is about 35,000 hr. A comprehensive programme is now under way in the U.S. to establish material strengths after repeated stress and temperature loadings.

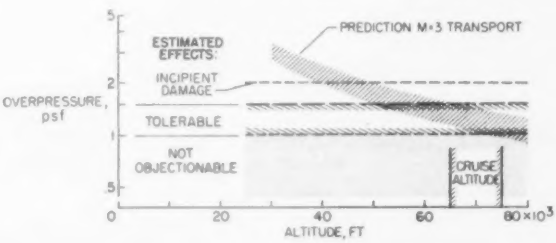
A U.S. programme is considered urgent if supersonic airliners are to be available in 1968-70. The potential market in the Western World then is put at 200 aircraft. The report is somewhat lukewarm on international co-operation in development, although it recognizes this could be mutually advantageous. "The supersonic transport presents problems of such scope and complexity that it cannot be developed successfully at any reasonable price without complete freedom from restraints on the best engineering and economic courses of action. This fact must be kept firmly in mind in any consideration of co-operation between governments."

A well-organized national effort is proposed. The F.A.A. would lead the programme and provide fiscal support. The Department of Defense (USAF) would be responsible for managing development and NASA would provide basic research and technical support.

Certain basic points are emphasized. The programme would cover Government *assistance* to industry for the development of a commercial aircraft. The principle of competition should be used to maximum advantage. Direct Government financial assistance should be provided only to the point in development where the aviation industry could carry on in accordance with their normal business practices.

The report is not dogmatic about cruising speed, saying that it will probably lie "in the Mach number range 2 to 3." But it states: "The economic benefit of higher speeds, along with technical considerations of speed-altitude effects on the sonic-boom intensity, tends to dictate flight at the higher speed and altitude. Accordingly, considerable emphasis has been placed on the structural design problems of M=3 flight." In general, Mach 3 appears to be the cruising speed favoured in the report.

Discussing a typical transport in detail, the report considers that take-off weight will be in the 350,000-400,000-lb. range and



CRUISE NOISE.—Shockwave effects at ground level will probably prevent the Mach 3 transport from cruising below 65,000 ft. The overpressures, in lb./sq. ft., are those produced at ground level.

take-off distances within current runway requirement. Cruise would be at Mach 3 between 65,000 and 75,000 ft. If present take-off and landing speeds are to be retained, the aircraft may well have a variable-geometry wing.

On the propulsion side, turbofans are favoured although turbojets could also be used. Although more time and money would be necessary for turbofan development, the turbofan "appears to offer sufficient advantage in the areas of take-off noise, flexibility and off-design efficiency to make its development appear highly desirable."

Noise is considered to be the major operating problem, both during take-off and in cruising flight. On take-off the turbofan could give an improvement over present noise levels, but the afterburning turbojet would be unacceptable. Sonic-boom noise when cruising at 65,000 to 75,000 ft. is considered tolerable. The report says that a major flight, wind-tunnel and theoretical programme is now under way to define the significant parameters of the sonic boom.

* "Commercial Supersonic Transport Aircraft Report." December, 1960. Federal Aviation Agency.

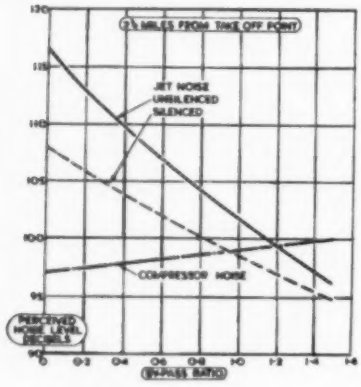
From the Lecture Hall . . . .

Aero Engine Developments

TRENDS in aircraft propulsion over the next seven years were discussed on Jan. 19 in a lecture by Mr. H. Pearson, B.A., F.R.Ae.S., M.I.Mech.E., Rolls-Royce chief engineer (performance and research). He was giving a main Royal Aeronautical Society lecture before the Southampton branch of the R.Ae.S.

In general, he forecast the performance and weight improvements which could result in the next few years. He emphasized the word "could"; not all the various types of engines would be developed with equal urgency. And a gulf of £10-12 million lay between the "possible performance" of an engine and its realization in a marketable form.

Engines for five general types of aircraft were discussed. They were subsonic jets, propeller turbines, supersonic transports, VTOL and STOL types and military aircraft. The military types were considered together because varying operational requirements made it more difficult to specify their engine requirements as distinctly as for civil aircraft. Also, security prevented precise figures being given. In addition, it now seemed questionable whether a new engine type would be financed for military purposes; requirements would probably be met by adapting an existing or proposed civil engine.



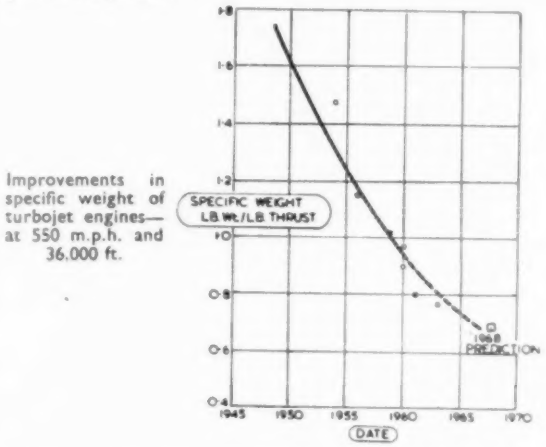
Noise versus by-pass ratio for a typical medium-range jet aircraft.

Discussing subsonic jet aircraft, Mr. Pearson said that the technical argument about by-pass engines had been resolved. He was now in the position of explaining why Rolls-Royce thought that high by-pass ratios were not the best solution; he no longer had to justify the by-pass principle.

The climate of opinion had changed because it had been found in America that the conversion of existing engines to "fan" engines was a fairly economical method of increasing their thrust, particularly for take-off. The effect of take-off noise on communities near airports had also acted as a strong catalyst in favour of the by-pass engine.

Almost overnight, from competing against the straight jet the by-pass engine was faced with competition from fan engines with a by-pass ratio around 1.5 : 1. "While admiring the speed with which these conversions of both faith and hardware were carried out, we have taken leave to doubt their correctness."

Mr. Pearson then gave the reasons for the Rolls-Royce view that with current operating temperatures the best ratio lay between 0.6 and 1.0. Take-off noise is reduced at higher ratios and this was one of the main reasons for using the top value of their range in the latest Rolls-Royce engines. The company was reluctant to go further because it believed that a steeply rising economic penalty was involved in using ratios well above 1.0, and also because such engines would have a higher landing noise.



Variation of direct operating cost and take-off noise with combustion temperature and by-pass ratio for a short-range transport.

Improvements in specific weight of turbojet engines—at 550 m.p.h. and 36,000 ft.

Cruising specific fuel consumption gradually improved with increasing by-pass ratio, but the improvement was very small above a ratio of 1.0. The improvement was reduced when allowance was made for power off-takes, bleed and thrust-reverser requirements. A higher by-pass ratio meant a larger engine diameter and hence a greater pod drag. Allowing for this, on the basis of "installed" s.f.c. about the greatest by-pass ratio which should be used was 1.2, and there was little gain in going above 1.0.

The variation of powerplant-plus-fuel-weight with by-pass ratio was examined for ranges of 1,500, 3,000 and 4,650 n.m. This showed that a by-pass ratio of about 0.8 was very near the best in all cases. The penalty in using engines of 1.5 by-pass ratio was about 3½% of aircraft weight—a large amount considering that payload of a long-range aircraft was only about 12% of its weight.

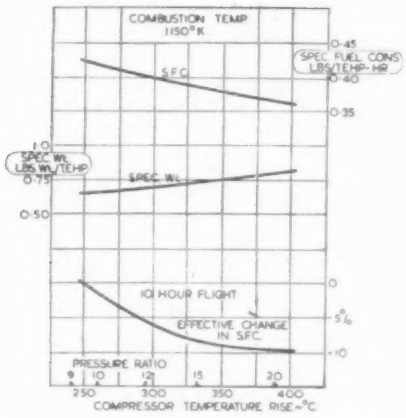
Even when comparing engines on a basis of take-off and landing noise, Mr. Pearson considered that little was to be achieved in raising the by-pass ratio above unity. A low take-off jet noise could be achieved with a high ratio, but only at the expense of a large economic penalty. And as jet noise decreased, compressor noise would become dominant.

When operating temperatures were increased, it became more worth while to use higher by-pass ratios. As combustion temperatures were raised, the jet velocities were increased with detriment to both propulsive efficiency and jet noise. A higher by-pass ratio would tend to rectify this situation without reducing the thrust compared with present engines.

It would probably be more sensible to think in terms of specific thrust level—thrust per unit air mass flow—than in values of by-pass ratio. For a given specific thrust the noise output and propulsive efficiency would remain constant. Mr. Pearson considered that these specific thrust values would remain constant in the next few years.

Discussing pressure ratio, he indicated how values had gradually increased over the years. For a given cruise combustion temperature, the s.f.c. diminished with increasing pressure ratio but the engine weight tended to go up because of the extra compressor and turbine stages. The relative importance of fuel consumption and engine weight was fairly well defined, and there was apparently little effective gain in s.f.c. to be achieved by higher pressure ratios.

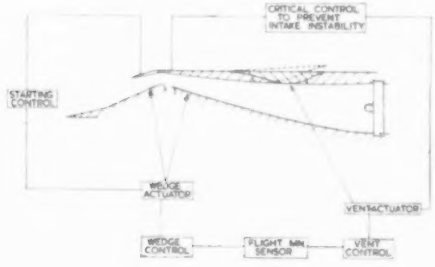
But the best value of pressure ratio depended on the combustion temperature used. If these temperatures increased



Effect of pressure ratio on powerplant performance for a turboprop engine—at 300 knots and 25,000 ft.

at anything like the current rate, it would be more worth while to use higher pressure ratios. Mr. Pearson believed that in about seven years a pressure ratio of 20 could be achieved without any basic modification to the two-shaft configuration of current engines.

Combustion temperatures were rising continuously. For a straight jet engine the combustion temperature had little effect on aircraft economics, but increased the take-off noise level. But at the higher by-pass ratios a very worth while improvement occurred. If by-pass ratio were increased with combustion temperature, the noise level could be kept constant while maintaining the best operating costs.



Supersonic aircraft intake control.

Mr. Pearson predicted that within seven years a cruising temperature of about 1,350° K could be achieved; the take-off combustion temperature would be about 1,450° K. He did not consider that it would be wise to rely on much improvement in component efficiency over that period.

Increases in pressure ratio and, to a lesser extent, in combustion temperature would tend to increase engine weight, although specific weight would be reduced. Further improvements would come from design developments; and these could be used to produce by 1967 a by-pass engine which would have the same specific thrust as today, producing the same thrust per unit airflow and compressor frontal area.

It would be in the 10,000-20,000-lb. thrust class and have a pressure ratio of about 20 and a temperature of 100° above that for current engines. By-pass ratio would be about 1.5 to 1.6; s.f.c. about 4% better; and specific weight about 10% lower. It should give an improvement of 6.7% in aircraft range compared with a 1960-62 engine.

Mr. Pearson discussed problems of reducing turbine and compressor noise, which became more significant than jet noise with engines of high by-pass ratio. The problem was mainly one of economic penalties associated with noise-reduction methods and the operating and airworthiness restrictions which might be imposed. Techniques included the use of variable-area intakes to choke the flow at approach conditions, and variable-area devices inside the engine. In the immediate future, minor improvements would probably be obtained from noise absorption and tuning devices in the engine nacelle.

Mr. Pearson said that turboprops had not developed at the same rate as pure jet engines because they had not been required to the same extent for military purposes and were intrinsically more complex. Improvements in performance would come through the raising of combustion temperature and pressure ratio and from improvement in design and weight. It would be wise to assume that the turboprop could benefit from the same technical developments as jet engines, by 1967.

Thus an engine of roughly the same size as the present Tyne could give a 16% power increase coupled with an 8% s.f.c. reduction for a given airflow. Airflow could be increased about 20%, giving a power increase of 34%. Making allowance for a heavier reduction gear would give a specific weight improvement of 20%.

The engine would have a take-off power of about 8,000 s.h.p. and would need a propeller of nearly 20-ft. diameter. The overall specific weight of engine plus propeller would remain the same.

Referring to the recent R.Ae.S. symposium on supersonic airliners (THE AEROPLANE AND ASTRONAUTICS, Dec. 16), Mr. Pearson pointed out that the overall engine efficiency of a turbojet was about 35% at Mach 2. But owing to the poor lift/drag ratio, a high installed thrust was needed and engines must be operated at high temperatures unless their weight and size were to be prohibitive. Cruising temperatures of about 1,350° K. would be necessary.

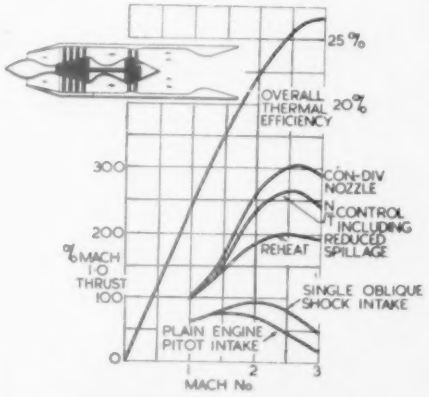
VTOL and STOL Types

For VTOL transport aircraft no completely acceptable solution had yet emerged from the many studies made. Perhaps this was because design had tended to incorporate various lifting systems into generally conventional aircraft designs. If low noise level was to be attained, low jet velocity was mandatory and more success might be achieved by designing the aircraft round a propulsion and lifting duct system. In any case, the solutions were so difficult to foresee that it was difficult to predict the trend of propulsion powerplants in this field.

Trends could be outlined for purely military aircraft, interceptor or strike aircraft, where VTOL might be required as an operational advantage or necessity. For the high performance interceptor, the thrust requirements would probably be so great that the propulsion powerplants could lift the aircraft off vertically. In this case the engines might be designed for the high-speed requirements, and VTOL achieved by rotating the powerplants (in external pods) into the vertical position, or by deflecting the jets downwards.

Two competing solutions were offered for strike aircraft, where a high Mach number performance is not required. In the first a combined by-pass powerplant is used to give a high thrust and the whole of the thrust was deflected at take-off, as with the Bristol Siddeley BS.53 engine in the Hawker P.1127. Its advantage was that only one powerplant was used; the disadvantage that in the subsonic cruising condition, because the installed thrust was so large, the engine was heavily throttled back and the consumption impaired.

The alternative solution was to provide the lift from special lightweight lift engines and to power the aircraft with a separate propulsion engine chosen for optimum propulsion performance. The latter might have a deflected jet for take-off if desired. The advantage of this solution is that optimum propulsion efficiency can be retained and safety in the event of engine failure ensured. Obviously the disadvantage lies in the provision of several lifting engines.



Potential thrust of a developed turbojet engine.

Britain's Future Efforts in Space

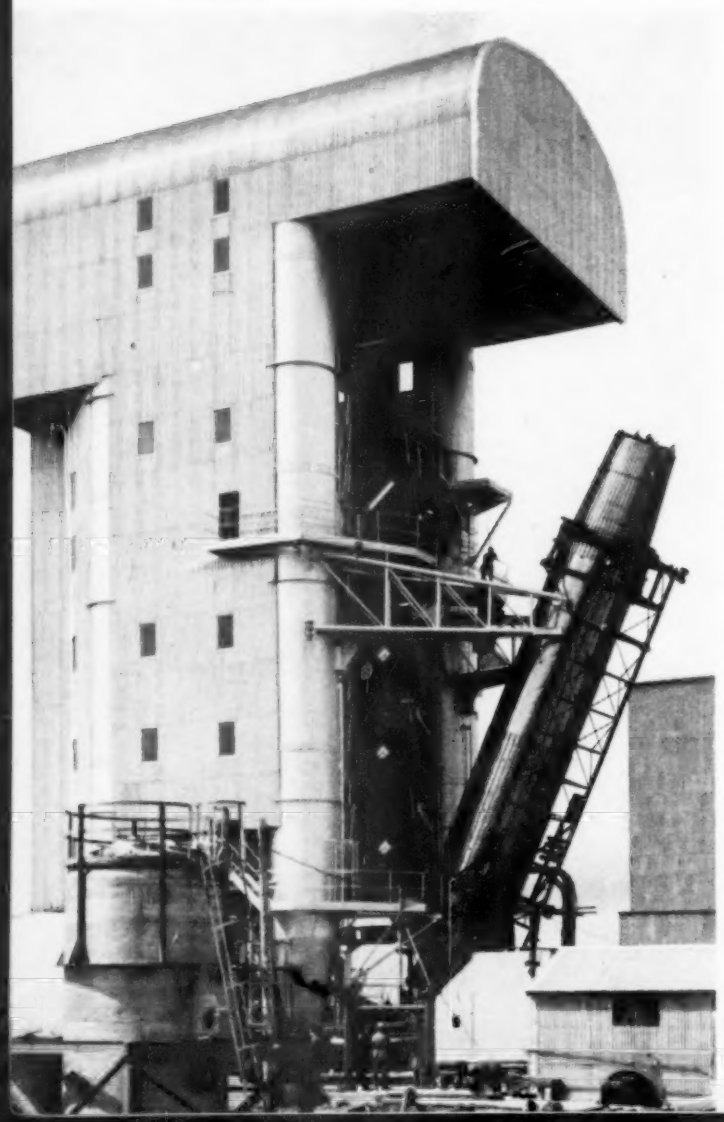
The author, S. W. GREENWOOD, M.Eng., A.M.I.Mech.E., A.F.R.Ae.S., believes that past indifference to the significance and commercial importance of astronautics has placed this nation in a subordinate position relative to other World Powers, and that our only scope for participation in this field lies in augmenting the United States space programme. Next week, A. V. CLEAVER will argue against Mr. Greenwood and make a case for European co-operation.

NINETEEN-SIXTY, as so many journals and newspapers have recognized, was in many respects a year of humiliation for Britain. In spite of signal successes in the aeronautical field, the cancellation of the only long-range rocket missile under development in this country, Blue Streak, left a bitter taste in everyone's mouth and started a first-class political row.

The blow was softened for some by the Government's decision to explore its potential as a booster for launching satellites. Here again, the spectacle presented has been a sad one, with the Minister of Aviation and senior advisers travelling to the countries of the Commonwealth and Europe in efforts to raise additional funds and support.

The seriousness of our weakness in the large rocket field becomes even more apparent when we reflect that, not only is Blue Streak a vehicle designed in the light of American experience with Atlas, and using data supplied by Convair Astronautics and an engine based on information supplied by Rocketdyne, but it is still suffering from the indignity of never having been tested in flight. Until that happens successfully, we cannot really talk of "having" Blue Streak.

While the space age gets into high gear all around us, it is salutary to pause from our utterance of high resolve and good intention and ask ourselves some tough questions and face up to some appalling weaknesses. For action is urgently needed to get us out of a desperate rut, and if we are to face honestly the issues that are certain to arise from now on at the political level, then the sooner we take a straight look at ourselves the better.



Blue Streak: springboard to a new technological future in space? Vehicle is seen here in the servicing tower at Spadeadam.

The nation's outward face expresses bewilderment and embarrassment. This has been brought about by past indifference on the part of three groups:—

1. *Scientists and Engineers.* The greatest blame lies with this group. With rare exceptions, men of science and engineering have seen fit to treat proposals for the exploration of space with scorn or indifference. It is tragic that those most likely to appreciate the significance of astronautics, e.g., astronomers, have often been most expressive in their outpouring of ridicule. The degree to which this hostility was entrenched may be appreciated by the fact that it was largely unaffected by the American announcement of a satellite programme for the I.G.Y., and only began to give under the shock of the first Russian launching two years later, in 1957. That the importance of space exploration is now widely recognized only underlines earlier bias.

2. *The Government.* While governments expect to be blamed for everything, this one must stand on record as the one that (with relatively minor changes) held office in the '50s and sounded an advance note on the approaching space age by pouring scorn on a suggestion by the then Mr. Robert Perkins, M.P. for Stroud and Thornbury, that it should set up a Select Committee to consider research into interplanetary travel. In case other parties take any comfort from this, it is necessary to note that they did not come to the assistance of the man under ridicule, so the indictment of indifference stands for the whole House.

3. *The People.* They took their cue from the two groups above, and stayed indifferent.

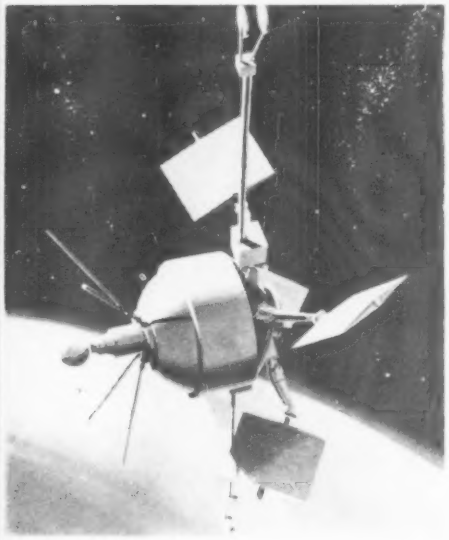
These judgments may seem unduly harsh, but when the present is a manifestation of past troubles, then it is vital for a start to root them out. In compensation let us consider the record of two organizations that emerge unscathed from this self-analysis:

1. *The British Interplanetary Society.* Founded prior to World War II, and noteworthy for its objectivity from the beginning, the B.I.S. recognized the German rocket developments as constituting a considerable advance towards providing the basis for space exploration vehicles. In spite of (and doubtless in part because of) general ignorance and indifference, a sufficient number of technical and non-specialist people worked energetically in the post-war years to keep the flag of astronautics flying, to attempt to derive new and better ways (on paper) of getting into space, and to influence public opinion. It has never compromised its objectives, nor altered them to suit shifting enthusiasms, and remains the only society in Britain devoted exclusively to astronautics. The B.I.S. certainly tried hard to get Britain into space at an early stage.

2. *Temple Press Limited.* If the reader interprets this as waving the publisher's flag for him, I would remind him of the exceptional contribution made by THE AEROPLANE during the critical years ushering in the space age, in presenting material of apparently limited immediate interest in astronautics, but now seen to be both relevant and even of urgent concern. In the book field, the publication of Arthur Clarke's brilliant and authoritative books in the early 1950s constituted major contributions to astronautics. It all seems obvious enough now, but in the light of the general scientific and "intellectual" climate of the time, it took both foresight and a sense of responsibility to issue those important works.

The 1960s

While we may take some pride in our contribution to aeronautical art as the 1960s get under way, it is desirable to take a look at the intentions of our American friends in the astronautical field. It still seems to some people that they are not



Artist's impression of NASA's S-51 international satellite, scheduled for launching by an American four-stage Scout rocket from Wallops Island late this year. It will carry some 20 lb. of scientific instruments designed and built in Britain.

so far ahead that we cannot catch up if we wish, but the facts are different. NASA has been quite open regarding its plans for this decade, and some of them are listed below:

1. Operational in 1962: Centaur, with Atlas as first stage and a second stage using liquid hydrogen and liquid oxygen. Capable of placing 4 tons into orbit close to the Earth, or soft-landing 200 lb. on the Moon.

2. Operational in 1963: Saturn, with clustered first stage and upper stages using liquid hydrogen and liquid oxygen. Capable of launching 10 tons into a close Earth orbit, or soft-landing 1 ton on the Moon.

The capability these vehicles will give the United States *in the course of the next few years* is considerably in excess of the most ambitious of the plans for Blue Streak (Ref. 1). Even before Centaur becomes available, Atlas will be used for launching a man into a close Earth orbit. The advent of Saturn will make possible manned circumlunar flights and the establishment of the first satellite "space stations."

In addition to the specific vehicle programmes mentioned above, high-thrust motors and nuclear motors are at an advanced stage of development, and will undoubtedly influence the rate of astronautical progress. Readers of this journal can be in no doubt of the intensive effort being applied over a wide front, and of the soundness and thoroughness of the American space programme.

What of the Soviet Union? One thing seems certain, and that is that her vehicle performance is likely to stay ahead of the American level. The Americans already concede that the Russians will be the first to put a man into space, and other vital stepping stones will be reached by them ahead of the rest of the World.

On the commercial side, the United States is now acquiring experience with both active and passive communication satellites, and commercial interests have detailed plans for communication systems based on this experience. The proposals of the American Telephone and Telegraph Company for 50 active satellites in random polar orbits, each having a mass of 175 lb., shows considerable promise. If the launching vehicles can be made available, such a system could be operational before the end of the decade.

The Prospects for Britain

Much has been said and written during the past year or two regarding our scope for entry upon a significant space programme. All these plans are based on an untested vehicle, and many suppose the ability to follow-on relatively quickly with liquid hydrogen rocket upper staging. In the light of developments elsewhere, it must be emphatically stated that such proposals could only come to fruition on too small a scale at too late a date. This is not to deny the sincerity or the sense of purpose of the adherents to such proposals, but simply to draw attention to the hopelessness of their case.

We cannot go it alone, in any direction that makes commercial sense. What are the alternatives?

1. *Leave it to others.* Do no large-scale work in astronautics. This would be spiritual death for science and technology in this country, as is now acknowledged.

2. *Co-operate with the Commonwealth.* The combined resources would be too small to be competitive, even were they capable of being combined, and they are not.

3. *Co-operate with Europe.* Good resources, but practically impossible to achieve co-operation owing to nationalistic traditions.

4. *Combine 2 and 3 above.* Unworkable for the reasons given.

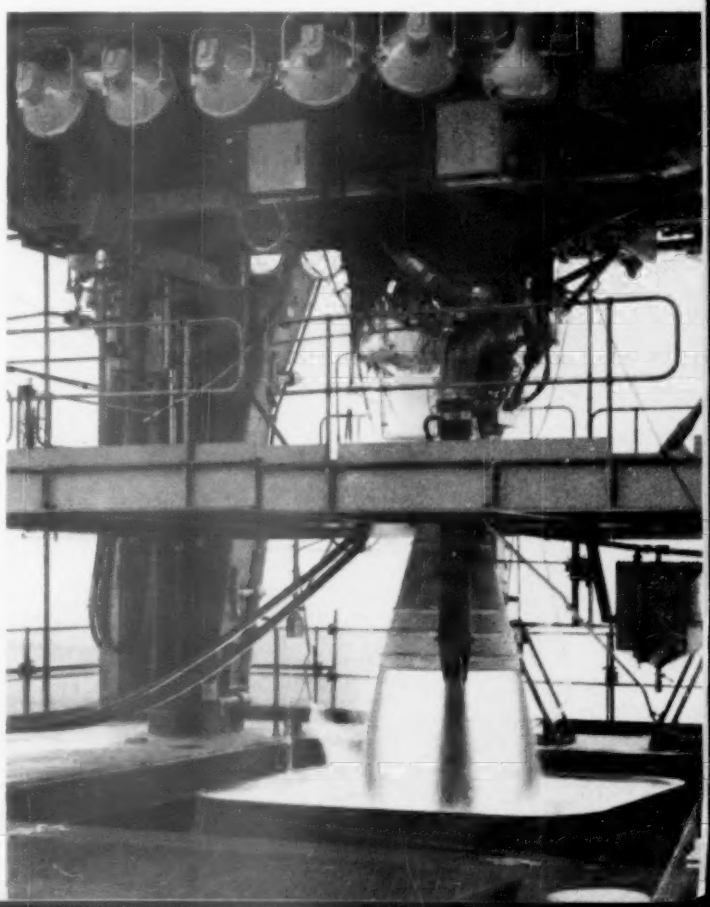
5. *Co-operate with the Soviet Union.* Ruled out by the political and even military overtones of astronautics, at present. The time cannot be far distant when Russia will make such an offer for prestige and propaganda purposes, however.

6. *Co-operate with the United States.* This is not only the one remaining alternative—it is the only practicable one. Such a state of affairs already exists to a greater degree than many are prepared to admit (Ref. 2). Quite apart from the offer of the Americans to provide Scout rockets and launching facilities (a technological contribution) to place British satellites in orbit (an essentially scientific contribution), we already have examples of co-operation on the technological level. Blue Streak itself is an example of this, and more recently British scientific equipment designed for a quite different purpose, the radio-telescope at Jodrell Bank, was used to track and send command signals to American space probes. At the military level, from which so many astronautical developments subsequently emerge, there is now a considerable measure of co-operation.

Is this co-operation proving of advantage to us? If not, then we must abandon it as quickly as possible, and be clear on our alternatives. If the co-operation is advantageous, then we should be enthusiastic about it, and make it a formal and recognized part of our national policy. Much of the confusion and muddle-headedness at present evident in matters affecting our relationship with the United States stems from our apparent unwillingness to face this issue squarely. Nowhere is the need for decisive thinking more urgent than in the astronautical field, as the proportions of the national budgets being allocated to this elsewhere are large and still rising.

The fact is that the co-operation is proving advantageous. On the American side we see, not merely a willingness, but an enthusiasm for more extensive co-operation. It is no more than good sense to work for this goal with a clear picture of its desirability and, indeed, inevitability.

That is the general objective. What of specific ends? Here the author offers only his personal views, realizing that only thoughtful and considered discussion can lead to understanding



Test firing of the Rolls-Royce RZ2 rocket engine, developed in this country under a licence agreement with North American Rocketdyne. Two such engines of 135,000 lb. s.t. are used in Blue Streak.

America's giant space-booster of 1.5m. lb. s.t. en route for the static test site at Huntsville, Alabama. A flight-weight prototype is shortly to leave by sea-going barge for the launching site at Cape Canaveral.

of those fields where participation should be undertaken, relinquished, or shared for the best advantage of the different parties.

The following guiding principles are suggested:—

1. In the early stages of development of a large and expensive technological system (such as a booster rocket) there is a *cost barrier* that makes it impracticable for this nation to undertake the work alone. This barrier must be established in round figures, and the temptation to go above it resisted. The author suggests that this figure lies around £100 million a year, or about 2% of the national budget, and is the sort of figure that was mentioned when the Blue Streak weapon system was cancelled. In this respect it may be argued that the revised proposals for using the vehicle as a satellite launcher (Ref. 1) involve much smaller sums, around £14 million a year. The figure strikes the author as optimistic, and he wonders if the advocates of such schemes would be prepared to guarantee the taxpayer against loss by undertaking to complete the programme if costs should rise above the estimate.

2. Space research and exploitation is of *inherently global concern*. Anyone who launches a communication satellite cannot help but make available a potentially world-wide facility. The objective in co-operative ventures should therefore be to make the most effective contribution from the global viewpoint. The exploration and exploitation of other Worlds will add emphasis to this perspective. A nation such as ours that contracts out of the development of large booster rockets can make its best contribution in the provision of tracking and communication facilities and assisting in specific research fields such as atmospheric entry and instrumentation development.

That this leads us to a state of dependence on the United States space programme is undeniable. The author differs from many of his contemporaries in seeing this as a necessary and desirable thing. It has at least one feature in its favour that wakens an echo of approval from its critics—it is a step in the direction of the conception of one World, a conception that is natural to the astronaut, and to which we in the Western World now have an opportunity of giving preliminary substance.

REFERENCES

1. "Britain and Space-technology." THE AEROPLANE AND ASTRONAUTICS, Nov. 25, 1960.
2. S. W. Greenwood. "The Future Pattern of Space Exploration." *Aeronautics*, Sept., 1960.

Industrial Participation in Space

AS the project for a combined European effort in space-research and technology gathers momentum, more British companies are taking active steps to enter the field. The latest is Decca Radar, Ltd., who are forming a group of senior engineers to inaugurate the company's research and development in the field of space electronics. The research team is to be established in new laboratory premises on the company's development site at Somerton Airport, Cowes, in the Isle of Wight. Initial programmes are expected to include tracking systems and low-noise receiving systems.

Pye, Ltd., of Cambridge, have had a small astronautics group in being for nearly two years. In collaboration with University College, London, they have developed equipment for measuring electron temperature, electron concentration, and ion mass spectra, in the first U.K./U.S. Scout-launched satellite S-51. The same team has been looking into the design of observation satellites.

An astronautics group has also been established by Pye Telecommunications. This section of the Pye organization has done valuable work in conjunction with the Nuffield Radio Astronomy Observatory, Jodrell Bank, in using the Moon as a passive reflector for radio signals. It was on May 14, 1959, that scientists from Manchester University at Jodrell Bank transmitted the first messages in Morse code and speech to America via the Moon. The radio equipment, which sent the messages a distance of half a million miles, was designed and manufactured by Pye telecommunications engineers.

Apart from Pye, Ltd., several other firms have been concerned in developing equipment for the U.K./U.S. satellite S-51. The Guided Weapons Laboratory of Bristol Aircraft, Ltd., for example, are producing an X-ray spectrometer package in conjunction with University College, London, and the Physics Department of the University of Leicester. McMichael Radio are producing equipment for the cosmic-ray experiment devised by Imperial College (the apparatus includes an E.M.I. photomultiplier), and G. and E. Bradley, Ltd., are concerned with Birmingham University's electron density equipment.

As we mentioned in our article on "Orbital Relay Stations" on Jan. 13, Elliott Brothers (London), Ltd., have a research and development contract for a stabilized space-platform. Although this equipment is intended for use in a satellite of between 1,000 and 2,000 lb., to be placed in a near-circular orbit at some 300 n. miles to act as an astronomical observatory, the techniques evolved would be equally valuable in developing an Earth-orientated communication satellite or an observation satellite.

The astronomers have requested it for mounting a small telescope and spectrograph for studying UV radiation from the stars. The project itself is an outgrowth of design studies for a satellite launcher based on Blue Streak and Black Knight made at the R.A.E., Farnborough, at the request of the Ministry of Aviation in 1959.

The fact that Hawker Siddeley Aviation were working on the design of a stabilized active communication satellite was made known to readers of THE AEROPLANE AND ASTRONAUTICS on Aug. 12 last year in an exclusive article written by Dr. W. F. Hilton, leader of the newly established Astronautics Section of the Advanced Projects Group. An operational system would consist of three satellite repeaters pursuing elliptical orbits inclined at 63° to the Equator, with the primary object of serving the telecommunications needs of the densely populated Northern Hemisphere. Weighing between 500 and 700 lb. each, they could be launched from Woomera by the proposed European heavy satellite launcher. Much detailed work has been done on this project in recent months.

As might be expected, other companies within the Hawker Siddeley Group have become involved in satellite studies. For example, Sir W. G. Armstrong Whitworth Aircraft, Ltd., have been working with Hawker Siddeley Aviation on the satellite payload, while the de Havilland Engine Co. have been looking into third-stage vernier propulsion for the proposed launcher and attitude stabilization problems.

A technical group of the de Havilland Aircraft Co. has also been concerned on the vehicle side and, in addition, has been evaluating various satellite communications techniques with the object of obtaining sound economic estimates of launching and running costs, etc. Both Hawker Siddeley Aviation and de Havilland Aircraft have been considering schemes for observation satellites.

Of further interest is that the Special Products Division of de Havilland Aircraft of Canada, of Downsview, Ontario, are involved with the structural design and manufacture of the S-27 Top-Side Sounder satellite on behalf of the Canadian Defence Research Telecommunications Establishment. This includes the development of special erection units for the long tubular antennæ.

The aerials are formed from steel tapes, the section of which restores to a full circle after extrusion from the guides. Similar techniques are now being considered for use in a possible British satellite at the Nuffield Radio Astronomy Laboratories for the purpose of conducting radio-astronomical observations above the Earth's atmosphere.

The S-27 satellite is, of course, part of a joint U.S./Canadian programme for studying the propagation of radio waves in the ionosphere, involving soundings both from above and below. It is expected to be launched by a Thor-Agena B rocket from the United States early next year.

Minitrack in Britain

WHEN the first U.K./U.S. satellite S-51 is launched from Wallops Island, Virginia, it is hoped within the next 12 months, one of the ground stations which will track it and acquire its telemetered information will be the Minitrack station which has been established at Winkfield in Berkshire.

Until recently, there have been 10 Minitrack stations operating in various parts of the World, principally in North and South America but including one in South Africa and one at Woomera in Australia. Four more are now being added for the purpose of acquiring satellites launched at higher inclinations to the equator.

The station nearing completion at Winkfield is one of them. Although all its equipment, including aerials and recording equipment, is American—on loan from NASA—operation of the station is entirely in the hands of British radio engineers from the Radio Research Station of D.S.I.R. at Slough.

The Winkfield station, and others in the World-wide network, will be used in conjunction with satellites transmitting in the 136-137 Mc/s frequency band. This is the new wavelength adopted for scientific satellites by international agreement in August, 1959, and has yet to be brought into practical use.

Until now, the Russians have been using frequencies of about 20 and 40 Mc/s., whereas the United States has largely used 108 Mc/s. The early Minitrack stations were, in fact, originally designed to work on this latter frequency. It remains to be seen which country will be first to achieve a satellite working on the new frequency; but what is certain is that the S-51 satellite which British scientists are instrumenting will do so.

Accurate determination of the satellite's direction in space is determined through the interferometer principle. Four fixed horizontal antennae have been sited with high precision due north, south, east and west. Opposing aerials are positioned approximately 100 yd. apart with an accuracy of ¼ in.

Position of the satellite is obtained by measuring the phase difference between radio signals emitted by its transmitter and received by the ground aerials; the phase difference represents the difference in time taken by the waves to reach the two aerials. Thus, by making simultaneous measurements of aerials set up on a N-S line and others on an E-W line, it is possible to convert the phase difference into the angle in space subtended by the satellite.

From time to time it is necessary to check the accuracy of the system and, for this purpose, a specially designed camera is mounted at its centre. An aircraft carrying a flashing light, controlled from Winkfield, and a transmitter is flown over the system on a clear night and photographed. The true direction of the aircraft at any given instant is found from the photograph, which shows the aircraft's position against the star background; this serves as a reference against which to compare the simultaneous radio measurements of direction.

It may be remarked here that the geographical co-ordinates of the Winkfield station were determined by Ordnance Survey to an accuracy of one cubic meter. Another vital element of the station's equipment is a crystal clock which provides timing marks—or "read-out" times—at one-second intervals, or less, to an accuracy of one-thousandth of a second.

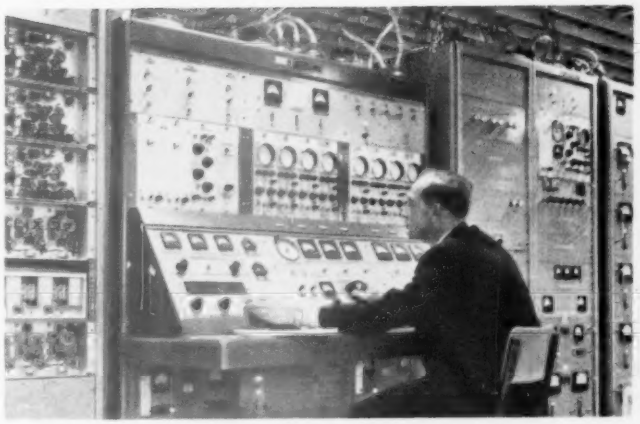
Equipment used for receiving telemetered results from satellites includes remotely controlled beamed aerials—one receiving on 108 Mc/s. and another on 136-137 Mc/s. The former has already been used in conjunction with the launching of Explorer VIII last November. There is also, of course, a receiver and a magnetic tape recorder.

The eight channels of the tape recorder are used for various functions depending on the particular satellite under observation. Generally, however, they record the signal strength, timing pulses derived from the crystal clock and signals of accurately known frequency (used for monitoring the speed of the tape) together with the essential telemetry information. Command signals can also be sent to the satellite to turn its transmitter on and off, and to operate the space-borne tape recorder, if such is fitted.

Winkfield is in direct touch with the Goddard Space Flight Center of NASA in the United States by two-way teleprinter. This circuit is used to convey count-down information from American launching sites and, in addition, provides up-to-date orbital parameters of all satellites in orbit.

The teleprinter system also provides a link with other research centres in the United States, including the Smithsonian Astrophysical Observatory, which analyses the optical observations obtained from the Baker-Nunn precision cameras set up in various parts of the World.

Apart from the U.K./U.S. satellite S-51, other research activities of particular interest to Britain will include the reception of telemetered data from apparatus flown in satellites to investigate the upper portion of the ionosphere. It has been stated that the Radio Research Station is to collaborate with American and Canadian scientists in two "topside sounder" experiments of this kind by receiving the data at Winkfield and at its outstations at Singapore and in the Falkland Islands. The information obtained in this way will be complementary to information concerning the lower part of the ionosphere which the Radio Research Station obtains from ground experiments.



Control console for the Minitrack interferometer system. Equipment producing standard frequencies and timing pulses is shown at right.

Doubts on U.S. Space Boosters

CRITICISMS contained in the report of the ad hoc committee set up by President Kennedy to inquire into the status of the U.S. missile and space programmes—reported in our issue last week—have included comment on the development of U.S. rocket boosters.

The present Mercury man-in-space programme, based on the Atlas, the report says, is marginal and if the Atlas proves inadequate for the job it may be necessary to push alternatives vigorously. The first possibility appears to be Titan, although it has not yet demonstrated the reliability which is required.

The Centaur rocket involves an entirely new technology and is still untested, the report continues. If difficulties develop in this programme within the next three or four months, prompt action to initiate an alternative is essential.

Development of the Saturn booster, with its eight clustered engines, should continue to be prosecuted vigorously. However, it would be dangerous to rely on Saturn alone for the solution of U.S. booster problems for two reasons: (a) it is intrinsically so complex that there is a real question whether it can be made to function reliably; and (b) it represents a maximum elaboration of present technology and provides no route for further development.

Therefore, the development of a very large single engine should proceed as fast as possible so that it may be a back-up for the Saturn cluster and a basis for future larger vehicle development. The present F-1 (1.5m. lb. s.t.) engine programme should be studied to be sure it is progressing fast enough and has enough promise of success to fill this rôle. If the technological step in going from the present 180,000 lb. thrust engines to 1.5m. lb. is so big as to make success marginal, a parallel development of a somewhat smaller engine should be started.

Of the nuclear rocket programme Rover, the report states that this presents an area in which some major decisions will have to be taken by the new administration. In principle the nuclear rocket can eventually carry heavier payloads much farther than any chemical rocket. Nevertheless, the technology is so new and the extrapolation from reactors developed now to sizes which would be useful in large rockets is so great that it is not clear how soon they will make an important contribution to the space programme. The use of nuclear rockets, it is stressed, will raise serious international political problems since the possibility that a reactor could re-enter and fall on foreign territory cannot be ignored. A major technical and management review of the Rover programme seems urgent.

Above all, the report says, the United States must encourage entirely new ideas which might lead to real breakthroughs. One such idea is the Orion proposal to utilize a large number of small nuclear bombs for rocket propulsion. This proposal should receive careful study with a realization of the international problems associated with such a venture

Personal Flying

PIPER prospects for 1961 include "considerably lower" profits, according to company president William T. Piper, because of tooling and development costs for the new PA-28 Cherokee, which has replaced the Tri-pacer in production, and a gloomy American economy. Sales of about 350 Cherokees are expected this year, together with at least 300 twin-engined Apaches and Aztecs and about 700 of the new two-seat Colts. The first Colt has already reached Kidlington.

Civil production for 1960, which was Piper's best year since 1947, amounted to 2,680 aircraft and resulted in a gross profit of more than $10 million. In addition to production of Fred Weick's new Cherokee design, the recently dedicated Piper plant at Vero Beach, Florida, is the location of development work on the PA-29 Papoose. This is an all-plastic low-wing two-seater with sliding bubble canopy and a tricycle undercarriage, aimed to sell at less than $5,000.

A new version of the PA-25 Pawnee agricultural aircraft is also being developed, with a derated 250-b.h.p. Lycoming developing 235 b.h.p.

• • •

It seems that the South African Government is to restore its annual £25,000 subsidy for the training of private pilots, provision having been made for this in the 1961 budget. When the subsidy was discontinued in 1959, officials of the South African flying clubs claimed that it would be the death-knell for private flying.

Prior to that time, for every pilot who had qualified, the Government had given £40 towards the £200 or so which it had cost him, and also £40 to the club where he had trained. Since the withdrawal of the subsidy, there had been a falling-off of club membership for flying training.

• • •

A prototype of the Victa Air-Tourer, the Australian two-seat light aircraft, recently left by ship for New Zealand, where it is spending a three-week demonstration tour. Six Air-Tourers, which are built at Sydney by Victa Consolidated Industries, have already been ordered by the Auckland Aero Club, and contracts for nearly 40 have been placed to date.

• • •

DE LUXE NEWCOMER.—Shorter undercarriages and pointed spinners give a sleeker line to most of the 1961 high-winged Cessna range, which features for the first time the Skyhawk—prestige version of the Model 172.

From the Mooney Aircraft Company comes the news that the wooden wing of its Mk. 20 and 20A designs has been replaced by a new all-metal stressed-skin structure with integral tanks. Originally designated the Mk. 20B, the all-metal Mooney is now known as the Mk. 21, and sales of about 330 are expected during the current year.

Some 700 of the single-engined Mooney four-seaters had been built between 1955 and 1960, with either the 150- or 180-b.h.p. Lycoming engine. The change to a metal wing was made to reduce production time, and because of the difficulty in obtaining skilled woodworkers. The new wing is reported to have resulted in improved handling, particularly at low speeds, although identical in contours to the wooden type.

• • •

• Exeter Aero Club has a new Chipmunk, G-ARDF, which has more than satisfied the members in appearance and performance, while Auster 'JIW apparently leaves nothing to be desired. First solos have been achieved by Messrs. K. Watts, P. Colvin, P. Segelman and J. Howe, while Mr. G. D'Souza and Cdt. R. Pomeroy have obtained their P.P.L.s.

• Flying activities were at a low ebb at the Lancashire Aero Club during December, although the Link Trainer was busy with members practising radio procedures. Just over 20 hr. were flown, and a Tri-Pacer may be rented.

Gliding Notes

by Dr. A. E. Slater

WAVES and thunderstorms are still running neck and neck for the honour of being responsible for gain-of-height records. They were set up in slope lift alone until 1929, when congested cumulus clouds took over. Then, in 1937, a wave near Grunau, in Silesia, was used for the record; it was beaten in a thunderstorm over the Wasserkuppe the next year, but the final pre-war record, 22,441 ft., was set up again in the Silesian wave.

In 1947 a Swedish thunderstorm produced a new record, but soon after that the Americans discovered the Bishop Wave, in California, and they still hold the absolute altitude record for both single-seaters and two-seaters. But their single-seater gain-of-height record was taken from them in a German thunderstorm in 1959, to be beaten again in a wave last December by S. H. Georgeson in New Zealand, as recently reported.

Women's records are now undergoing a similar alternation, for Betsy Woodward's 27,995 ft. gain in the Bishop Wave in 1955 has been beaten by Mrs. Anne Burns, of R.A.E. Farnborough, in a South African thunderstorm, with 30,500 ft. gain, a World record for women and a British national record, while her absolute altitude, 35,000 ft., more than doubled her own British women's record. Flying Boet Dommisse's Skylark 3 from Kimberley on alternate days, she and her husband have broken a number of other records too. Anne has flown a 300-km. triangle at 42.25 m.p.h. (World and British record for women), 200-km. triangle at 49 m.p.h., and 268 miles out-and-return (both are World women's and British national records), and 325 miles distance (British women's). Dennis has set up a World out-and-return record of 353 miles, beating his wife's British one.

* * *

LAST year's Russian gliding championships were held in the Ukraine in such poor weather that there were only three official contest days. The tasks flown were a 100-km. triangle, a 200-km triangle, and a 150-km. straight-line race. Winner was Viktor Goncharenko, the leading baritone at Kiev State Opera House, who somehow finds time to be Russia's leading sailplane pilot as well.

At the 1958 World Championships in Poland, Goncharenko was the only Russian entrant in the Standard Class, but he performed much better than his three colleagues in the Open Class. I hear he has written a text-book on soaring.

Of the latest batch of World gliding records homologated by the F.A.I., the majority are Russian.

* * *

YORKSHIRE GLIDING CLUB announces 12 instruction courses of a week each, open to non-members, between the end of April and the end of September. The site is Sutton Bank, between Thirsk and Helmsley.

In the Club's latest *Newsletter*, David Rennison describes a remarkably skilful flight across the Pennines from the Yorkshire Club to the Lakes Club at Tebay, on a day when no one else could keep up for more than 20 minutes. Too much cumulus had formed on what had looked a promising day at first, and sunlit patches were sparsely distributed over the ground. Feeble thermals to 1,500 ft. enabled him to cross the valley to Ripon, whose hot air lifted his Kite 2 to 2,000 ft.

Then, in among the Pennine valleys, a 5-knot wind, blowing against south-facing slopes, was reinforced close to each hillside by a sort of generalized thermal lift which the meteorologists call an "anabatic wind."

The first anabatic wind lifted him 300 ft. above the hill-top; but on the second occasion the lift area was only continuous up to hill-top level, above which it broke into intermittent bits which could not be circled in. From the top of the third anabatic area he caught sight of the Lakes Club in the distance.

At this point the influence of an approaching cu-nim enabled him to climb to 4,500 ft. in clear air and explore the surrounding hills before landing at Tebay.

* * *

FROM Lasham to Terlet, the Dutch National Gliding Centre north of Arnhem, is 314 miles. Mr. M. J. Manting, head of the Terlet Centre, has announced that the first sailplane pilot to arrive there from Lasham will be given a free aero-tow back as far as the Continental coast at any point which suits his (or her) convenience.

Correspondence

The First Simplicator

I NOTE a letter in the Dec. 16 issue, which just came to hand, from Mr. Maurice Austin of Birmingham. I think I can answer Mr. Austin's questions.

I have a copy of Mr. Stout's book, which is really an autobiography, entitled "So Away I went!" by William Bushnell Stout. It was published by the Bobbs-Merrill Company, Inc., of New York, in 1951. On p. 135 of this book, Mr. Stout credits one of his associates, Gordon Hooton, with the expression "Simplicate and add more lightness."

Mr. Stout goes on to say further that he had written to Mr. C. G. Grey about this time on something else. He said, in a later letter, that he quoted the drafting room motto noted above as being the fundamental of their airplane design. He further went on to say that this seemed to appeal to C.G.'s sense of humour, who had placards printed and sent to all the aircraft drafting rooms in England so that for several years "thereafter I received considerable correspondence on that slogan, and requests for new ones."

Mr. Stout is not very specific as to dates about this time, but from the context this was in the very early twenties, possibly 1920 itself, and not later than 1923.

Denver 18, Colorado, U.S.A. A. F. BONNALIE.

Slowly . . . and Automatically

THE editorial in the Jan. 13 issue of THE AEROPLANE AND ASTRONAUTICS ends with the words "It is quite clear that there is still a paramount need for an aeroplane that lands slowly." Might I suggest the addition of the words "or automatically"?

Cheltenham, Glos. D. L. BROWN.

Swing-Tail First

MY issue of THE AEROPLANE AND ASTRONAUTICS for Nov. 25, 1960, reached me only recently and on p. 701 it has a picture of the Canadair CL-44D-4 and the statement that this is the first aeroplane with a hinged tail section.

Surely, the Parnall Panther introduced into the R.A.F. in the 1920s had a hinged tail section?

Sydney, N.S.W. F. KIRK,
Australia. (Air Cdre. R.A.F. (Retd.).)

[Our correspondent is, of course, correct. We should have made it clear that the CL-44D is the first freighter to fly, we believe, with a swing tail.—ED.]

Fatality Rate Statistics

I SHOULD like to thank Mr. F. G. Swanborough for pointing out my error. I agree that the figure of 10.3 is correct if the heading of the last column (THE AEROPLANE AND ASTRONAUTICS, Nov. 11 last, page 642) "Fatal accidents per 100,000 aircraft hours flown" means, number of fatal accidents to passengers per 100,000 aircraft hours flown, and not number of accidents to aircraft in which there were fatalities per 100,000 aircraft hours flown. Now Col. 2 headed "fatal accidents" is clearly number of accidents to aircraft in which there were fatalities, as Col. 3 gives passengers killed. (In 1959 22.3 per accident.)

It is suggested that the correct figure is $10.3 \times 22.3 = 230$.

Taking Col. 4 and assuming an average speed of 200 m.p.h., 212 is obtained.

To summarize:—

The fatality rates per 100 million passenger hours are:—

Car and taxi = 75.
Bus = 4 Train = 9.
Aircraft = 200 to 250.

Brough, Yorks. A. H. CRAWSHAW

[Mr. Crawshaw's figure of about 230 seems to be correct, and can be derived from the ICAO figures of 8.9 million aircraft hours, 32 passengers per aircraft and 629 fatalities. On the same basis, the 1960 figure was 250.—ED.]

Safety by the Yard—or Minute?

IN case nobody else takes the trouble to do so, I should like to dispute Mr. A. H. Crawshaw's claim (Jan. 6) that transport safety should be measured in relation to time spent travelling rather than to distance travelled. Although it is true that faster travel is increasing the amount of travelling by the average person and that, to that extent, we are all being exposed to more travel risks, there can surely be no argument that distance travelled is the only logical comparative yardstick for travel safety statistics. We travel—except in a cruise ship or possibly in our cars on the Brighton Road on a Sunday—to get from one place to another and what the passenger is concerned with is the risk associated with making that journey.

It would be small comfort to know that the vehicle to be used was so slow and safe that the passenger ran no risk of accident whatsoever and would be able to complete his natural life span before reaching his destination!

Ruislip, Middx. PETER W. BROOKS.

Pegoud and the Half-bunt

REFERRING to the Editorial comment on Mr. W. M. Bunce's letter (Dec. 2) and his second letter published in the Dec. 23 issue, I am able to confirm without any doubt that in the course of M. Pegoud's first demonstration of looping in this country at Brooklands on the second Saturday of September, 1913, he also flew upside down for, I would say, a full minute.

It was the first Saturday of the winter term and as an eager

Wroundabout

Burning Question. Do you remember the schoolboy jingle about the unfortunate consequences of a certain lad's inability to distinguish water (H_2O) from sulphuric acid (H_2SO_4)? It's been brought up to date:

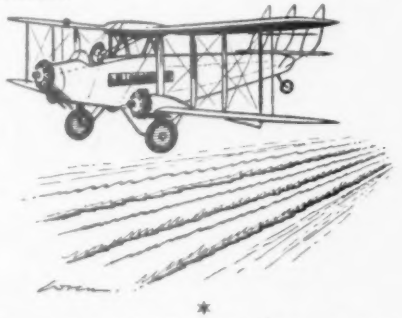
Little Willy's dead and gone
His troubles now are o'er,
What he thought was kerosene
Was really JP.4.

*

Evans rides again. That critical chronicler and chronic critic Stanley H. Evans has written a 700-word letter from Santa Monica pointing out that this column (not *Wren*, of course) erred wildly in speaking of a Vickers VC.1000. There was, he says, the V.1000, a military transport, and the civil version was to be the VC.7, "the most promising civil jet we or anyone else have yet done—or rather undone . . . but for the tragic decision of B.O.A.C. we could have had a fully operational VC-7B (with jet flaps) on British Commonwealth airways by 1960." A mistake is almost justified when it evokes one of S.H.E.'s long and outraged letters.

*

Prime Movement. Fascinating how our flying machinery changes. Some ancient biplanes had the elevator in front, rudder at the back, engine in the middle; then it settled down to engine in front, tail at the back; now engines are moving to the tail end, and in the big supersonic jobs the tail may go back (?) to the front. Up at Hatfield, engine reversal is complete—the first D.H. multi-engined airliner, the D.H. 66 Hercules, had three in front, the D.H. 121 Trident has three at the back. It's a sort of Hercules replacement.



*

"In this organization we have a powerful incentive—one mistake and you're fired."

*

Words, Words. A Guernsey supporter of Wroundabout, flying home by B.E.A. from London, was handed a Flight Report which stated that they were passing over the Isle of WHITE. Actually, the First Officer, who wrote the report, used to fly B.O.A.C.'s Far East routes until passengers complained of his spelling. His aircrew category assessment is: "A good pilot, but doesn't know Wight from Wong."

by Wren

13-year-old I went by push bike and stood precariously on a fence, lacking the shilling to go in. M. Pegoud climbed in a wide spiral to about 3,000 ft., building up terrific suspense. To get inverted he did a half-bunt, losing remarkably little height, remained upside down for the full length of the track and half-looped out. So B. C. Hucks was not the first "half-bunter" as you suggest in your reprint of the Pratts advertisement in your Dec. 23 issue.

Pegoud's loop followed a 45-degree dive and was, I should say, the tightest ever. I remember this day most vividly because I was able to shoot a line about it for the rest of that term and his flight plan was recorded pictorially on the inside back cover of my Latin grammar for many years after.

From that day I was determined to be a pilot, which I became five years later.

Hatfield, Herts. D. S. BROOKES, Gp. Capt., R.A.F. (retd.).

The Swept-propeller Identified

REGARDING the correspondence about the scimitar-bladed propellers in use at Brooklands in the 1912-1914 era by Vickers, these were Levasseur propellers, the licence for which was held by Vickers. A very good photo of one is in the Vickers advertisement on page 77 of THE AEROPLANE of Jan. 23, 1913. The blades are swept forward.

Hintlesham, Ipswich. H. J. PARHAM, Major-General.

[The founder-editor of THE AEROPLANE, the late great C. G. Grey, always said that it was more important to include the advertisement pages than the text pages in bound volumes—the historical value of the former would be higher!—ED.]

A Killing Cure

TWO airliners under strict control collide in the dense traffic area over New York. To prevent a recurrence of this type of accident, the forces of professionalism start a pressure campaign to impose strict control over the (bar London) practically empty air of the U.K. Surely there are two *non sequitur* here?

Dr. Bergin and the Guild tell us their scheme to implement this will not hurt us, in the mixture of soothing and minatory terms adopted by a doctor when he tells his patient to relax and shut his eyes, and it won't hurt. In this case, however, the patient knows better than the doctor—the proposed operation will kill him, and anyway, the doctor is mistaken, it's the other fellow who is ill.

If gliding is to be annihilated, let it not be by mistake or on a false premise.

London, W.1. P. A. WILLS, Chairman, B.G.A.

Books and Publications Received

World Aviation Directory—Winter 1960-61. Edited by Marion E. Grambow. Comprehensive guide, of particular value as a reference to the U.S. industry. 1,238 pp.; 5 in. by 7½ in. American Aviation Publications, Ltd. Price $13.00.

Kerosene versus JP.4

(*Continued from page 82*)

to the hazard due to rapid flame-spread across the liquid fuel spillage.

Regarding kerosene, this will only be explosive at such temperatures as may be obtained during tropical operation. But even in the tropics, all landings (except possibly those on very short haul work) will be made with kerosene below the weak limit of the explosive envelope.

All the above information is obtained from basic fuel inflammability data (Ref. 1, corrected version). If Sir William Hildred and Mr. Dyment maintain that these data do not apply to the conditions obtaining in an aircraft tank, then would they please say why, and also present some *evidence* in support of their viewpoint.

Para. 13. If Mr. Dyment is referring to static build-up in flight, I do not see how the fuel itself can become charged, regardless of its type, considering that it is contained within a metal envelope. But when the airframe discharges static (or if a tank is struck by lightning), if this occurs in the region of a badly designed tank vent, there is indeed a possibility of explosion if the tank contains an explosive vapour/air mixture. This is more likely to occur with JP.4 than with kerosene for reasons already explained. Once again, refer to report Ref. 6.

Regarding static build-up during ground refuelling, it was once believed that kerosene did generate more static than JP.4, but the most recent research carried out by the Shell Company in this country has shown that there is no difference between the two fuels in this respect.

Para. 14. Whether or not an engine tends to build up carbon deposits is a matter of combustion system design. And if kerosene jeopardizes the reliability of an engine to the extent Mr. Dyment claims, I would expect the engine type certificate to quote two overhaul lives, a longer one for JP.4, and a shorter one for kerosene. This is not the case with any British engine and I doubt if it is true of any non-British engine either.

Para. 15. Smoke generation appears to be a problem with certain non-British engines when using water injection. Again it is a question of combustion system design.

Para. 16. Mr. Dyment is being inconsistent. If kerosene really jeopardizes the safety of an engine in flight as he is claiming, its use should obviously be banned.

Before concluding, it must be admitted that my answers to some of Mr. Dyment's allegations may not appear satisfactory in those cases where he is referring to the shortcomings of non-British engines. My own experience is limited entirely to British (all Mr. Dyment's turbine engines are British). But, unless contrary evidence is produced, I just do not believe that any engine with a civil type certificate is in any way unsafe when burning kerosene.

REFERENCES

[1] Jet Fuel and Safety—*Flight*, Jne. 10, 1960, with corrections in *Flight* Jne. 17, 1960.
[2] Mechanism of Start and Development of Aircraft Crash Fires. NACA Report 1133, 1953.
[3] Origin and Prevention of Crash Fires in Turbojet Aircraft. NACA Report 1363, 1958.
[4] Fire Hazard Properties of Aviation Fuels (Ground Handling). National Fire Protection Association. N.F.P.A. No. 413M., May, 1960.
[5] Fuels for Turbine Transports. S.A.E. Journal, June,1956.
[6] Investigation of Lightning Hazards to Aircraft Fuel Tanks. Lightning and Transients Report No. 333. December, 1956.

Aviation Calendar

Jan. 30

Coventry.—Lanchester College of Technology Rocket Engine Technology lecture course, "The Use of Heat in Rocket Engines," by E. G. D. Andrews, at the College, at 19.00 hrs.

Jan. 31

London Airport.—Institute of Transport, West Middlesex Group, lecture, "Air Transport in Russia Today," by Capt. G. A. Yarotski, in the Lecture Theatre, Queens Building, L.A.P. Central, at 18.30 hrs.

Feb. 1

London.—R.Ae.S. Agricultural Aviation Group lecture, "The Economics of Agricultural Chemicals and Fertilizers," by J. C. Pinder, in the Lecture Theatre, 4 Hamilton Place, W.1, at 19.00 hrs.

London.—Kronfeld Club lecture, "Army Flying—Part 2," by Maj. P. A. Downward, in the Basement, 74 Eccleston Square, S.W.1.

Hatfield.—R.Ae.S. Branch lecture, "Operational Experience of the Comet 4B," by E. R. Major, in the de Havilland Restaurant, at 18.15 hrs.

Hull.—R.Ae.S. Brough Branch lecture, "Research at the College of Aeronautics, Cranfield," by Prof. A. J. Murphy, in the Royal Station Hotel, at 19.30 hrs.

Feb. 2

Swindon.—R.Ae.S. Branch Main lecture, "Nuclear Propulsion for Aircraft," by A. D. Baxter, in the College, Victoria Road, at 19.30 hrs.

Feb. 4

London.—British Interplanetary Society lecture, "Some Aspects of Solid Propellent Rocket Motors," by R. Heron, in the Kent Room, Caxton Hall, S.W.1, at 18.00 hrs.

Company Notices

NEW COMPANIES

CAMAIR, LTD. (679,272).—Private co. Reg. Jan. 2. Cap. £100 in £1 shs. Air chartering agents. Directors: Peter J. Dixon, 16 Chesterfield Road, Cambridge; Stanley W. Reynolds, 554 Coldhams Lane, Cherryhinton, Cambridge. Sec.: A. G. Young. Sols.: Ellison and Co., Cambridge. Reg. off.: 9 Sussex Street, Cambridge.

R.B.C. DEVELOPMENT CO., LTD. (679,369).—Private co. Reg. Jan. 2. Cap. £100 in £1 shs. Manufacturers of, dealers in and agents for power packs, internal combustion engines, petrol, diesel, rotary, jet and turbo-jet engines. Directors: Anthony H. Rushton, 47 Links Road, Epsom; Peter J. Cooper, Beech Hill, Downs Way, Tadworth. Sec.: William F. Bunn. Reg. off.: 61 Brushfield Street, E.1.

OVERLAND & AIR FREIGHTS, LTD. (679,576).—Private co. Reg. Jan. 4. Cap. £200 in £1 shs. Shipping and forwarding agents, ship and aircraft owners. Directors: Cyril T. Franks and Mrs. Joyce V. Franks, both of 91 Englands Lane, Loughton, Essex. Sec.: Vera Lee. Reg. off.: 22 Albion Buildings, E.C.1.

New Patents

862,380.—**Blackburn Group, Ltd., and Clark, F. M.**—"Assemblies for use in dropping loads by parachute from aircraft."—Jan. 20, 1959.

862,479.—**Rolls-Royce, Ltd.**—"Gas-turbine engine."—Jne. 18, 1959 (Jne. 27, 1958).

862,476.—**Soc. Nationale d'Etude et de Construction de Moteurs d'Aviation.**—"Jet-propelled aircraft."—Apr. 18, 1958 (Jne. 18, 1957).

Printed specifications of the above will be available on Mar. 8, 1961, and the opposition period will expire on Jne. 8, 1961.

Personal Notices

BIRTHS

Ashwood.—On Jan. 12, at R.A.F. Hospital Nocton Hall, Lincoln, to Gillian (*née* Roseveare), wife of Flt. Lt. John Ashwood—a daughter.

Cumming.—On Jan. 13, Newtownards Hospital, Co. Down, to Jennifer (*née* Howard), wife of Sqn. Ldr. Lindsay Cumming—a son.

Garby-Czerniawski.—On Jan. 14, at St. Mary Abbots Hospital, to Thelma (*née* Garby-Turner), wife of Wg. Cdr. Roman Garby-Czerniawski—a son.

Lee.—On Jan. 7, in Colombo, to Beryl (*née* Watts), wife of Sqn. Ldr. Pat Lee—a son.

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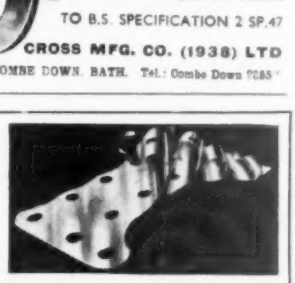

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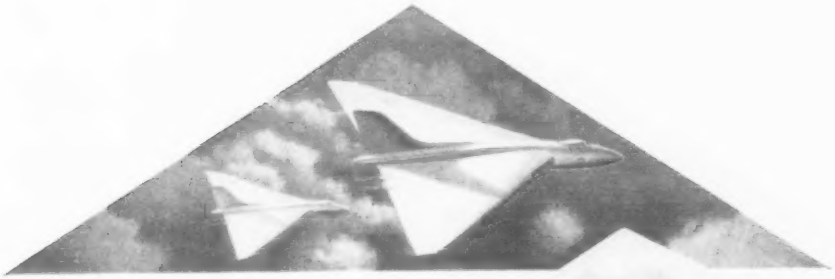

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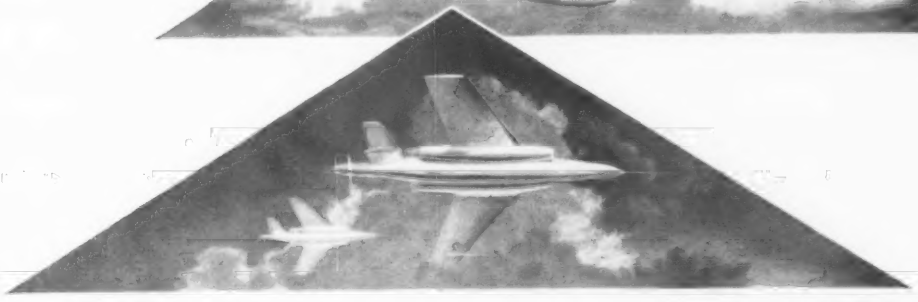

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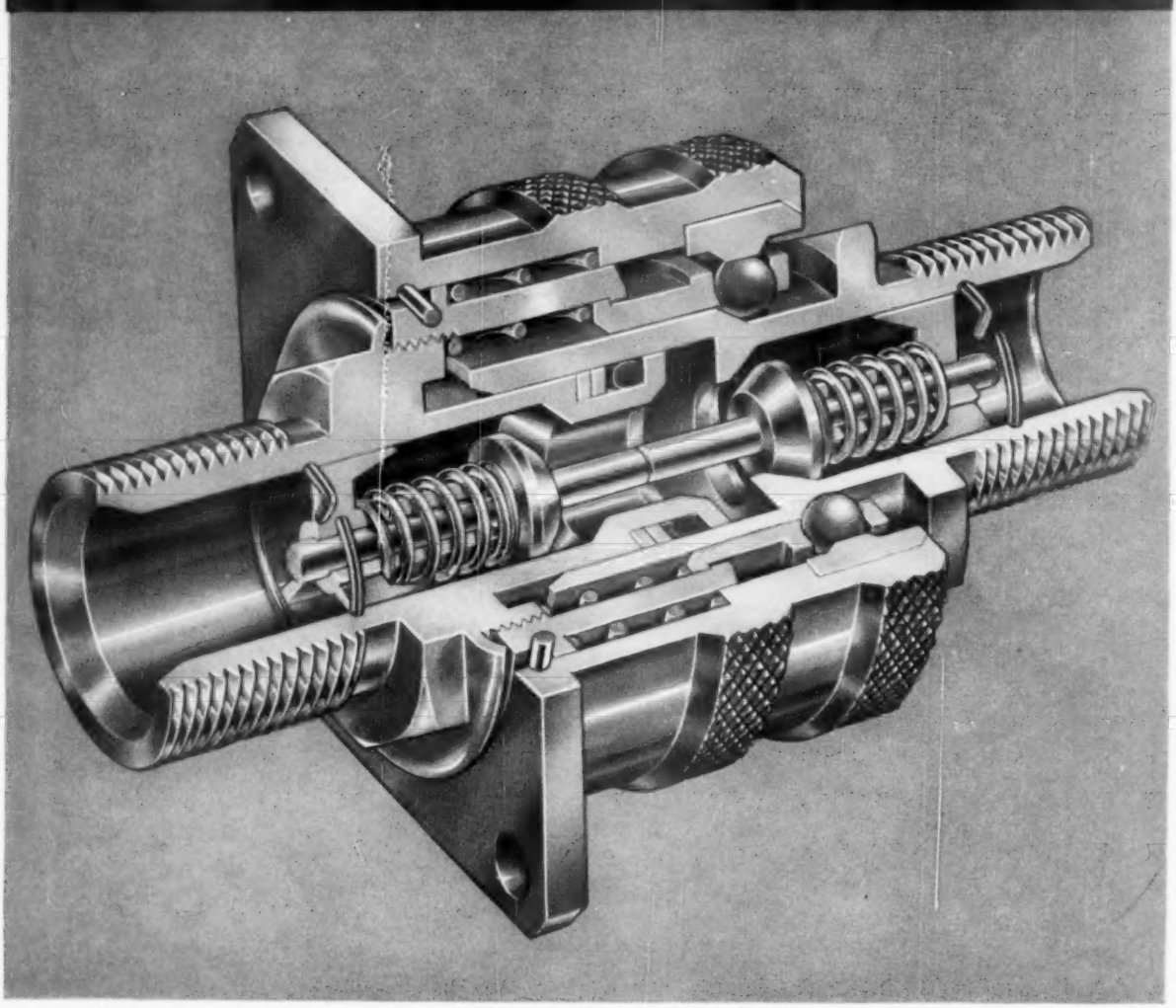

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